A

# DICTIONARY

OF

# CHEMISTRY.

CONTAINING THE

THEORY and PRACTICE of that SCIENCE:

ITS APPLICATION TO

NATURAL PHILOSOPHY, NATURAL HISTORY, || MEDICINE, AND ANIMAL ECONOMY:

WITH

Full Explanations of the QUALITIES and MODES of ACTION of CHEMICAL REMEDIES:

AND THE

FUNDAMENTAL PRINCIPLES

OF THE

ARTS, TRADES, and MANUFACTURES,

DEPENDENT ON CHEMISTRY.

TRANSLATED FROM THE FRENCH.

WITH

NOTES, ADDITIONS, and PLATES.

THE SECOND EDITION.

TO WHICH IS ADDED, AS

AN APPENDIX,

A

TREATISE on the Various Kinds of PERMANENTLY ELASTIC FLUIDS, or GASES.

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A

# DICTIONARY

OF

# CHEMISTRY.

## SAFFRON

SAFFRE. *See* ZAFFRE.

SAFFRON. *(a)*.

SAFFRON *of* IRON. Chemists have given the name *saffron* to many preparations which have a yellow color, like that of saffron, and particularly to the earth or rust of iron which has that color.

As iron may be deprived of its phlogiston by the combined action of air and of water, by that of air and fire, and, lastly, by acids, different names have been given to saffrons of Mars, or ferruginous earths prepared by these several agents. The rust of iron made by humid air is called *mar-*

*(a)* SAFFRON. Both water and spirit extract the color and virtue of saffron. The former liquor improves the smell and heightens the color, whilst the spirit seems rather to weaken both. By drying two ounces and a half of the best saffron in the heat of a water-bath, half an ounce of liquor was obtained, which had an exceeding strong smell, but had not the appearance of oil. This is the active part of the saffron, which disorders the head and senses. Six drams of extract were obtained from an ounce of dried saffron by means of water, and five drams and one scruple were obtained from another ounce by means of spirit. Rectified spirit acquired no smell or taste by distillation from dried saffron; but water being thus distilled acquired a strong smell. *Neuman.*

*tial saffron prepared with dew*, or *aperitive saffron of Mars.* Iron, dephlogisticated by vitriolic acid or sulphur, is also called *aperitive saffron of Mars.* Lastly, that which is reduced into a calx by the action of fire, is called *astringent saffron of Mars. See, for the medicinal virtues of these preparations of iron, the articles* ETHIOPS MARTIAL *and* IRON.

As the saffrons of iron acquire different shades of red and orange colors, which they preserve when melted with very fusible vitrified matters, they are employed for painting on enamel, on pottery, porcelain, and for giving color to glass, or imitations of precious stones.

SAFFRON *of* METALS. Saffron of metals is the metallic earth of antimony, half deprived of its sulphur and phlogiston by detonation of crude antimony with nitre, and afterwards well washed; or it is liver of antimony deprived of all saline matter by a sufficient washing. This preparation is a violent and uncertain emetic, not used by prudent physicians. *See* LIVER *of* ANTIMONY, *and* TARTAR (EMETIC).

SALMIAC. This word is an abridgement used by some for sal ammoniac. *See* AMMONIAC (SAL).

SALT. The word salt, which is synonimous with saline matter or saline substances, when taken in its most general sense, is of all chemical terms that which is applicable to the greatest number of individuals. In fact, the number of different bodies, which have what chemists call a saline character, or which possess the principal saline properties, is so great that they are very far from being all known, as we shall afterwards see.

The essential properties of all matter which ought to be considered as saline, are, to affect the sense of taste, to be soluble in water, and to have all the principal qualities, as gravity and fixity, in an intermediate degree betwixt those of water and of pure earth.

If we attend a little to the principal properties of the several bodies which are considered as salts or saline substances, we shall easily find that they do not all possess in the same degree the essential saline qualities that we have described. We shall see that some salts possess these qualities in the highest degree, while in others they are so weak and indistinct, that in many of them they can scarcely be discovered; and this diminution of the saline properties is so considerable in many compound bodies, that we may affirm that the limits which separate saline matters from others that

that are not ſaline, are unknown, indeterminate, and perhaps incapable of being determined.

We are certain, on the other ſide, that the ſaline ſubſtances whoſe properties are moſt diſtinct and ſtrong, ſuch, for inſtance, as the mineral acids, have great power over many other ſubſtances which have not a ſaline property; to which, by being combined together, they communicate more or leſs of their ſaline properties; or rather with which they form compounds, in which the ſaline properties are more or leſs ſenſible. Since experience ſhews that theſe ſaline compounds may be decompoſed, ſo that the ſubſtance, which is not ſaline, ſhall be ſeparated in its former ſtate from the ſaline matter, which alſo ſhall recover the ſaline properties in the ſame force which it had before this union, we may from thence conclude;

Firſt, that among the infinite multitude of bodies in which we may perceive ſaline properties, a very great number are compoſed of a ſubſtance eſſentially ſaline, and of one or more other ſubſtances not ſaline.

Secondly, that we ought to diſtinguiſh well ſubſtances which eſſentially poſſeſs ſaline properties from thoſe which, not poſſeſſing any ſuch properties themſelves, are only capable of receiving more or leſs of them by uniting with ſubſtances of the former kind.

Thirdly, as the number of matters not ſaline which are capable of acquiring a ſaline character, or rather of forming compounds more or leſs ſaline by their union with ſubſtances eſſentially ſaline, is very great, the number of theſe laſt muſt be very ſmall, in compariſon of the number of compounds in which ſaline properties are perceptible.

To give ſome explanation of this extenſive ſubject, we muſt begin by determining preciſely what ſubſtances eſſentially ſaline are; and by aſſigning a character which can diſtinguiſh them from thoſe, which, without containing any thing ſaline, may nevertheleſs make part of ſalts, by the union they are capable of contracting with the former. Theſe characters are the following:

All thoſe ſubſtances ought to be conſidered as eſſentially ſaline which have not only the characteriſtic properties of ſalts, as taſte and perfect miſcibility with water, in an eminent degree, but which alſo when diſengaged can communicate theſe properties, at leaſt in part, to the other ſubſtances which have them not, by combining with theſe latter, from which, when afterwards ſeparated, they reſume their former ſtate and peculiar ſaline characters.

All acids and alkalis, mineral, vegetable, or animal, fixed or volatile, fluid or concrete, muſt be conſidered as ſubſtances eſſentially ſaline. Each of theſe bodies has the properties we have mentioned. Some other ſubſtances have not the properties of acids or of alkalis very diſtinctly; but as they have the properties of ſalts in general, and are capable of acting as acids, and of communicating ſaline properties to the compounds into which they enter, they may therefore be conſidered as ſubſtances eſſentially ſaline. Such are *arſenic* and *ſedative ſalt*.

But if we reflect a little on the particular properties of each of the ſubſtances which ſeem to be eſſentially ſaline, we ſhall obſerve that they do not all poſſeſs theſe properties in the ſame degree. How great the difference is in this reſpect betwixt pure, concentrated vitriolic acid and the acid of tartar! They can ſcarcely be known to be ſubſtances of the ſame kind. The taſte ſimply acidulous of cream of tartar, its ſtate of conſtant cryſtallization and dryneſs, its little ſolubility in water, laſtly, the weakneſs of the adheſion which it contracts with all the ſubſtances with which it can unite, cannot be compared with the ſtrong and corroſive taſte of vitriolic acid, with the activity of its ſeizing moiſture, with the ſurprizing heat occaſioned by its mixture with water, laſtly, with the extreme force that keeps this body united to all the bodies with which it is capable of combining. The ſlighteſt view of the other ſubſtances eſſentially ſaline is ſufficient to ſhew that they differ much from each other, particularly in their degree of ſtrength; in a word, that they do not poſſeſs the ſaline properties in the ſame degree.

Theſe are the conſiderations which have undoubtedly determined the greateſt chemiſts, particularly Stahl, to believe that the number of ſubſtances truly and eſſentially ſaline is very ſmall, and even that only one ſaline principle exiſts, which by the intimate union it is capable of contracting with ſeveral other ſubſtances, conſtitutes a certain number of matters which poſſeſs the ſaline properties in a degree ſufficiently ſtrong to preſerve theſe properties more or leſs in their ſeveral combinations with other matters that are not ſaline, and to recover them entirely when ſeparated from theſe combinations; ſo that as they do not themſelves undergo any decompoſition, and as they always appear again with the ſame properties after having been combined and ſeparated, they ſeem to be ſimple matters, eſſentially ſaline, although they really are compounds of ſeveral bodies,

dies, not ſaline, united intimately with one only ſaline principle, which is univerſal and always the ſame.

According to this notion, which is grand and perfectly analogous to the plan which nature ſeems conſtantly to purſue in the different orders of compounds, the queſtion is to diſcover which is the moſt ſimple of all ſaline ſubſtances, and is the principle of all others. The beſt, and perhaps the only, method of determining in a queſtion of this nature, is to compare together the ſeveral ſaline ſubſtances, and to conſider that as the moſt ſimple of all, which poſſeſſes the ſaline properties in the moſt eminent degree, and which alſo appears upon all occaſions to be leaſt ſuſceptible of decompoſition or alteration; for all chemiſtry ſhews us, that theſe are the characters of the moſt ſimple bodies, which are capable of becoming principles of more compound bodies: but when we examine all the ſaline matters under this point of view, we ſhall ſoon eaſily diſcover that we muſt begin by excluding all the ſaline matters called *neutral ſalts*; for any of theſe ſalts may be decompoſed by ordinary chemical operations; and theſe decompoſitions ſhew that many of them are compoſed of two ſimpler ſaline ſubſtances, one of which is called *acid*, and the other *alkali*; alſo, acids and alkalis are not in general ſo eaſily altered as neutral ſalts. In the claſſes therefore of theſe two ſaline ſubſtances, we muſt ſearch for that which is the moſt pure and ſimple of all.

If we continue this inquiry upon the ſame principles, and compare together the ſaline properties of the pureſt and ſtrongeſt acids and alkalis, we ſhall eaſily be convinced that the ſaline properties are ſtronger and more diſtinct in acids than in alkalis, ſince the former are more active, more diſſolving, more adhering to the bodies diſſolved, more deliqueſcent, &c. and alſo, that in the ſeveral operations of chemiſtry, alkalis fixed and volatile appear to be more ſuſceptible of alteration and decompoſition than acids. Amongſt acids, therefore, we muſt ſearch for the ſtrongeſt and ſimpleſt ſaline matter.

Laſtly, when we examine in the ſame manner, and compare together all the ſubſtances which have the principal properties of acids, and which are called acids, we ſhall clearly perceive that thoſe which are truly vegetable and animal, that is, in the combination of which oil enters, are infinitely more weak and ſuſceptible of alteration than acids deprived of all oil, which we call mineral acids; amongſt which, the vitriolic will be eaſily diſcovered to be

the ſtrongeſt and moſt unalterable, and conſequently of all bodies which have ſaline properties, the pureſt, ſimpleſt, and the moſt ſenſibly and eſſentially a ſalt.

Such conſiderations have undoubtedly induced the moſt profound chemiſts, and eſpecially the illuſtrious Stahl, to conſider this acid as the pureſt and ſimpleſt of all ſaline matters; and indeed all who are capable of reflecting on the greateſt and moſt important phenomena of chemiſtry, will conſider this propoſition as a demonſtrated truth. But Stahl carries this notion ſtill farther. From his writings, and the whole of his doctrine, we may infer, firſt, "That "he conſiders the vitriolic acid as the only ſubſtance eſſen- "tially ſaline; as the only ſaline principle, which, by "uniting more or leſs intimately with other ſubſtances that "are not ſaline, is capable of forming an innumerable "multitude of the other ſaline matters which nature and art "ſhew to us; and, ſecondly, that this ſaline principle is a "ſecondary principle, compoſed only of the intimate union "of two primary principles, *water* and *earth*."

Every true chemiſt will eaſily diſcover that this grand idea is capable of comprehending by its generality, and of connecting together, all the phenomena exhibited by ſaline ſubſtances. But we muſt at the ſame time acknowledge, that when we examine the proofs upon which it is founded, although it has a great appearance of truth by its conſiſtency with the principles of chemiſtry, and with many phenomena, yet it is not ſupported by a ſufficient number of facts and experiments to aſcertain its truth.

We might here examine what degree of probability ought to be granted to this theory of ſalts, but this could not be properly accompliſhed without entering into long details, and penetrating into the depths of chemiſtry; in a word, without making a full and compleat treatiſe, which cannot be admitted in a work of this nature. We are therefore obliged to relate only what is moſt eſſential to be known concerning this grand hypotheſis. We may perceive at once, that the former of theſe propoſitions, upon which is founded the theory which we mentioned, cannot be demonſtrated, unleſs it be previouſly proved that every ſaline matter, excepting pure vitriolic acid, is nothing but this ſame acid differently modified, the primary properties of which are more or leſs altered or diſguiſed by the union contracted with other ſubſtances. But we confeſs, that chemiſts are not capable of proving deciſively this opinion; which,

which, however, will appear very probable from the following reflections.

First, of all saline matters known, none is so strong, so unalterable, so eminently possessed of saline properties, as *vitriolic acid.*

Secondly, amongst the other saline substances, those which appear most active, and most simple, as *nitrous* and *marine acids*, are at the same time those, whose properties most resemble the properties of vitriolic acid.

Thirdly, we may give to vitriolic acid many of the characteristic properties of nitrous acid, by combining it in a certain manner with the inflammable principle, as we see in the volatile sulphureous acid. *See* ACID (VOLATILE SULPHUREOUS), *and* ACID (NITROUS): and even, according to an experiment of Mr. Piech, related in a Memoir concerning the origin of nitre, which gained the prize of the Academy of Berlin, vitriolic acid, mixed with vegetable and animal matters susceptible of fermentation, is really transformed into a nitrous acid by the putrefaction of these matters.

Fourthly, the marine acid, although its principles are less known than those of the nitrous acid, may be approximated to the character of vitriolic and nitrous acids by certain methods. This acid, after it has been treated with tin and other metallic matters, is capable of forming ether with spirit of wine, as vitriolic acid does, which it cannot do in its natural state; and when iron is dissolved in it, it seems to be approximated to the nature of nitrous acid. Reciprocally, the approximation of vitriolic acid to the character of marine acid seems not impossible. Having once distilled very pure vitriolic acid upon a considerable quantity of white arsenic, I was struck with a strong smell like that of marine acid, which was not either that of arsenic or of vitriolic acid; for this has no smell, when it is pure.

Fifthly, oily vegetable acids become so much stronger, and more similar to vitriolic acid, as they are more perfectly deprived of their oily principle, by combining them with alkalis, earths, or metals, and afterwards by separating them from these substances by distillation, and especially by frequently repeating these operations. They might perhaps be reduced to a pure vitriolic acid, by continuing sufficiently this method: and reciprocally, vitriolic and nitrous acids weakened by water, and treated with much oily matters, or still better with spirit of wine, acquire the

characters of vegetable acids. We may see a remarkable instance of this in Mr. Pott's *Dissertatio de Acido Nitri Vinoso*.

Sixthly, the properties of fixed alkalis seem to be very different from those of acids in general, and consequently of vitriolic acid. Yet if we consider that a large quantity of earth enters their composition; that much of it may be separated by repeated solutions and calcinations; and also that by depriving these saline substances of their earthy principle, they become less fixed, more deliquescent, and, in a word, more similar to vitriolic acid in this respect; we shall not think it improbable, that fixed alkalis owe their saline properties to a saline principle of the nature of vitriolic acid, but much disguised by the quantity of earth, and probably of inflammable principle, to which it is united in these combinations. The properties of volatile alkalis, and the transformation of fixed alkali or of its materials into volatile alkali in putrefaction and in several distillations, seem to shew sufficiently that they are matters essentially saline, as fixed alkalis are, and that their volatility which distinguishes them proceeds from their containing a less quantity of earth, but more attenuated, and a portion of very subtle and volatile oil, which enters their composition.

Besides these principal facts, there are many others, too numerous to be even slightly mentioned here: they may be found scattered in the works of chemists, particularly of Stahl. But persons who would collect and compare all the experiments relating to this subject, ought to know, that many of them are not sufficiently ascertained, and that perhaps a greater number of them have not been sufficiently prosecuted, and are, properly speaking, only begun. We must even acknowledge, that many of those experiments which we have mentioned have not been sufficiently prosecuted. *See all the articles of Acids and Alkalis.*

The second fundamental proposition of the theory of salts, namely, "that the vitriolic acid is compounded of only the "aqueous and earthy principles," is, like the first, supported by many facts which give it a degree of probability, but which do not amount to a compleat demonstration. This proposition may be supported by the following considerations.

First, experience constantly shews, that the properties of compound bodies are always the result of those of the component parts of these bodies, or rather they are the properties of these component bodies modified by one another.

Thus,

Thus, if a body be compoſed of two principles, one of which is fixed and the other volatile, it will have a leſs degree of fixity than the former, and a leſs volatility than the latter. If it be compoſed of two principles, one of which is ſpecifically heavier than the other, its ſpecific gravity will be greater than that of one of them, and leſs than that of the other. The ſame obſervation is applicable to all the other eſſential properties, excepting thoſe which deſtroy each other, as, for inſtance, the tendency to combination, or the diſſolving power; for theſe latter properties are weakened ſo much more in the compounds, as their principles are more ſtrongly united, and in more juſt proportion.

We obſerve nevertheleſs, that the properties of compound bodies are not always exactly intermediate betwixt the properties of the component bodies; for, to produce this mean, the quantities of each of the component parts muſt be equal, which is the caſe in few or no compounds.

Beſides, ſome particular circumſtances in the manner in which the principles unite with one another, contribute more or leſs to alter the reſult of the combined properties; for inſtance, experience ſhews, that when ſeveral bodies, particularly metals, are united together, the ſpecific gravities of which are well known, the allay formed by ſuch union has not the preciſe ſpecific gravity which ought to reſult from the proportion of the allayed ſubſtances; but that in ſome allays it is greater, and in others leſs. But we are certain, on the other ſide, that theſe differences are too inconſiderable to prevent our diſtinguiſhing the properties of the principles in the compounds which they form, eſpecially when they have very different properties.

Theſe things being premiſed, when we examine well the properties of vitriolic acid, we ſhall eaſily find that they partake of the properties of the aqueous and of the earthy principles.

Firſt, when this acid is as pure as we can have it, it is like the pureſt water and the pureſt vitrifiable earths, free from color or ſmell, and perfectly tranſparent.

Secondly, although we cannot deprive the vitriolic acid of all the water ſuperabundant to its ſaline eſſence, and therefore its preciſe ſpecific gravity has not been determined, we know that when it is well concentrated, it is more than twice as heavy as pure water, and much leſs heavy than any earthy ſubſtance.

Thirdly,

Thirdly, this acid is much less fixed than any pure earth, since, however well it may be concentrated, it may always be entirely distilled; for which purpose, a much stronger degree of heat is requisite than for the distillation of pure water.

Fourthly, we do not know the degree of solidity of vitriolic acid, or the *adhesion of aggregation* which its integrant parts have one to another, because for this purpose the vitriolic acid ought to be deprived of all superabundant water; but if we judge of it by the solid consistence of this acid when highly concentrated, as we see from the vitriolic acid called *glacial*, the integrant parts of this acid seem susceptible of a much stronger adhesion than those of pure water, but much less than those of earth, as we see from the instance of hard stones.

Fifthly, the union which this acid contracts with water and with earths, shews that these substances enter into its composition: for we know that in general compounds are disposed to unite superabundantly with the principles which compose them. All these properties of vitriolic acid, which so sensibly partake, and much more than any other acid, of the properties of earth and of water, are sufficient to induce us to believe that it is composed of these two principles; but it has one very eminent property, which is common with it to neither water nor pure earth, which is, its violent and corrosive taste. This property is sufficient to raise doubts, if we could not explain it from principles which seem certain and general, relating to the combination of bodies. We shall here summarily recapitulate them, although we have spoken of them in several articles of this work, particularly at the words AFFINITY, AGGREGATION, SOLUTION, COMPOSITION, GRAVITY, SATURATION.

We observe then concerning the property now in question, that is, of taste in general, that it can only be considered as an irritation made upon the organs of taste by sapid bodies: and if we reflect attentively upon it, we shall be convinced that no substance that is not impressed by some impulse, can irritate or agitate our sensible organs, but by a peculiar force of its integrant parts, or by their tendency to combination, that is, by their dissolving power. According to this notion, the taste of bodies, or the impression made upon our sensible organs by their tendency to combination, or by their dissolving power, are the same property; and we see accordingly, that every solvent

has

has a taste which is so much more strong, as its dissolving power is greater; that those whose taste is so violent that it amounts to acrimony, corrosion, and causticity, when applied to any other of the sensible parts of our body besides the organs of taste, excite in them itching and pain.

This being premised, the question is, how earth, in which we perceive no taste nor dissolving power, and water, which has but a very weak dissolving power, and little or no taste, should form by their combination a substance, such as the vitriolic acid is, powerfully corrosive and solvent?

To conceive this, let us consider, first, that every part of matter has a power by which it combines, or tends to combine with other parts of matter. Secondly, that this force, the effects of which are perceptible, in chemical operations, only among the very small molecules, or the integrant and constituent parts of bodies, seems proportionable to the density or specific gravity of these parts. Thirdly, that this same force is limited in every integrant molecule of matter; that if we consider this force as not satisfied, and consequently as a simple tendency to combination, it is the greatest possible in an integrant molecule of matter perfectly insulated, or attached to nothing, and is the smallest possible, or none, when it is satisfied by its intimate combination with other parts capable of exhausting all its action; its tendency is then changed into adhesion.

Hence we may infer, that the integrant parts of the earthy principle have essentially, and, like all the other parts of matter, a force of tendency to union, or of cohesion in union, according to their condition; that as this earthy principle has a much more considerable density or specific gravity than all other simple bodies that we know, we may probably presume that its primary integrant molecules have a more considerable force of tendency to union, in the same proportion, than the integrant parts of other principles; that consequently when they cohere together, and form an aggregate, their aggregation must also be stronger and firmer than that of any other body. Accordingly we see that the purest earthy substances, whose parts are united and form masses, such as, for instance, the stones called vitrifiable, are the hardest bodies in nature. We are no less certain, that as the tendency of the parts of matter to unite is so much less evident as it is more exhausted and satisfied in the aggregation, the parts of the earthy principle being capable of exhausting mutually all their tendency to union, we may thence infer, that every sensible mass of pure earthy matter

matter muſt appear deprived of any diſſolving power, of taſte, in a word, of tendency to union, from the firmneſs of its aggregation. But we may alſo infer, that when theſe primary integrant parts of the earthy principle are not united together in aggregation, then, reſuming all the activity and tendency to union which are eſſential to them, they muſt be the ſtrongeſt and moſt powerful of all ſolvents.

Theſe being premiſed, if we ſuppoſe again, with Stahl and the beſt chemiſts, that in the combination of the ſaline principle or of vitriolic acid, the parts of the earthy principle are united, not with each other, as in the earthy aggregation, but with the primary parts of the aqueous principle, each to each, we may then eaſily conceive that the primary integrant parts of the water having eſſentially much leſs tendency to combination than thoſe of earth, the tendency of theſe latter to union will not be exhauſted, but ſatisfied only partly, by their combination with the former, and that conſequently a compound muſt reſult, the integrant parts of which will have a ſtrong diſſolving power, as vitriolic acid is.

We may ſee from hence how much miſtaken chemiſts are, who, conſidering earth only in its aggregation, or rather not attending to this ſtate, and not diſtinguiſhing it from that ſtate in which the parts of this ſame earth are ſo ſeparated from each other by the interpoſition of another body, that they cannot touch or cohere together, have conſidered the earthy principle as a ſubſtance without force or action, and have very improperly called that a *paſſive principle*, which of all others is the ſtrongeſt, moſt active, and moſt powerful.

However this general theory of ſalts may conform with the moſt important phenomena of chemiſtry, we muſt acknowledge that it can only be propoſed as a ſyſtematical opinion, till it be evidently demonſtrated by the deciſive means employed in chemical demonſtrations, namely, by decompoſition and recompoſition: thus, if we could reduce vitriolic acid to earth and water, and make that acid by combining together theſe two principles, this theory would ceaſe to be a ſyſtem, and would become a demonſtrated truth. But we muſt confeſs that this theory is leſs ſupported by experiment than by argument, from the many difficulties that are inevitable in ſuch inquiries. For on one ſide, we know that the ſimpler bodies are, the more difficult is their decompoſition; and on the other ſide, the

ſtronger

ſtronger the aggregation is, the greater is the difficulty of making it enter into a new combination. Thus, as vitriolic acid is very ſimple, ſince it is a compound of the firſt order, it ought ſtrongly to reſiſt decompoſition: and as the aggregation of pure earth is the firmeſt that we know, it cannot eaſily be made to enter as a principle into a new combination with water to form a ſaline matter. The following are the principal experiments which have been made relative to this ſubject.

Firſt, we ſeem to be certain, from many proofs, that all ſaline ſubſtances, comprehending thoſe that contain vitriolic acid, as vitriolated tartar, Glauber's ſalt, and other vitriolic ſalts which are ſufficiently fixed to ſupport a perfect drying, or rather calcination, being alternately diſſolved, dried, and calcined a number of times, are more and more diminiſhed in quantity, and that earth and water are ſeparated from them each operation. But alkaline ſalts appear to be ſtill more ſuſceptible than any other ſaline matter of this kind of decompoſition.

Secondly, when nitre is burnt in cloſe veſſels, ſo that we may retain not only all that remains fixed after this burning, but alſo what exhales in vapors, as in the experiment of the clyſſus of nitre, we have a proof which ſeems deciſive, that the mineral acid of this ſalt, which is not very far from the ſimplicity of vitriolic acid, is totally decompoſed and reduced into earth and water. For if we examine the fixed reſiduum in the retort, we find that it is only the alkali that was contained in the nitre, charged with a ſuperabundant earth, which is ſeparable from it by ſolution and filtration. And if the liquor in the receiver, formed by the vapors condenſed there, be examined, which ought to be nitrous acid, if this acid had not been deſtroyed, we find that, ſo far from being acid, it is only pure water, ſometimes even charged with a little fixed alkali, which had been raiſed by the force of the detonation. Thus nitrous acid is made to diſappear in this experiment, and in its place we find only earth and water. *See* ACID (NITROUS), CLYSSUS *of* NITRE, DETONATION *of* NITRE, *and* NITRE.

Thirdly, the phenomena of limeſtone, which by calcination and extinction in water acquires ſaline properties that it had not before, its attenuation by fire, and its combination with water; and alſo the experiment of Beccher, who aſſerts, that if a vitrifiable ſtone be alternately made red-hot and extinguiſhed in water a number of times, it may be ſo

ſo attenuated, that it ſhall be like a ſaline gelatinous matter; theſe, I ſay, ſhew that ſaline matters are actually formed by the intimate combination of the very attenuated parts of earth with thoſe of water. We find in the writings of Beccher and Stahl, and particularly in the *Specimen Beccherianum* of the latter author, many other obſervations and experiments tending to prove the ſame propoſition; but we muſt confeſs that none of the experiments we have mentioned, excepting that of the decompoſition of nitrous acid by burning, are abſolutely deciſive, principally becauſe they have not been ſufficiently repeated, or proſecuted, nor carefully enough examined in all their circumſtances.

Such is the actual ſtate of the beſt theory of ſaline ſubſtances hitherto given. However fine and probable it may ſeem, it requires to be further illuſtrated, and better proved, eſpecially by experiments. They who love inquiries into the ſublimeſt parts of chemiſtry cannot engage in a more intereſting ſubject.

As ſubſtances eſſentially ſaline, and particularly thoſe of their combinations which are called *ſalts*, are very numerous, we ſhall here merely enumerate them, that we may have them at one view. For the details we refer to the particular article of each of theſe ſaline matters. We ſhall ſee by this kind of view, that although many combinations are known, many alſo are not known, becauſe they have never been made; and many others are known but imperfectly, becauſe they have not been ſufficiently examined.

Subſtances eſſentially ſaline are, acids, alkalis, and neutral ſalts with baſis of alkali.

The ſimpleſt and ſtrongeſt acids, called *mineral acids*, are, *vitriolic acid*, called alſo *univerſal acid*, or *ſaline principle*.

*Nitrous acid*, commonly called *ſpirit of nitre* or *aqua-fortis*

*Marine acid*, called alſo *ſpirit of ſalt*, and *acid of common ſalt*. *See all theſe articles.*

The acids leſs ſimple and leſs ſtrong than the mineral acids are thoſe which have entered into the combinations of vegetables and animals, and which are united to a certain quantity of oil more or leſs attenuated. Theſe are cryſtallized eſſential acid ſalts, ſuch as *tartar*, called *cream* or *cryſtals of tartar*, when it is purified. *See* TARTAR.

The *acid of vinegar*, which proceeds from an acid fermentation, and is itſelf not only oily, but alſo ſpirituous. *See* VINEGAR.

The

The *unfermented acids of sharp fruits and plants*, as the juice of *gooseberries*, *citrons*, *sorrel*, &c. These acids have not been examined.

The acids and acid spirit obtained in the distillation of vegetables, of their extracts, essential salts, oils, balsams, and resins. As all these acids are united to an empyreumatic oil, they may be called *empyreumatic acids*. They have not been examined.

The *acids obtained from animal substances* are:

The acid obtained in the distillation of *ants*, *flies*, and other *insects*; and the acid obtained in the distillation of *butter* or of *fat*. These acids are empyreumatic; they are very volatile, pungent, and penetrating. They have not been examined. *See* BUTTER *and* FAT.

*Phosphoric acid*, the origin and nature of which are not so well known that we can determine to what kingdom it belongs. *See* PHOSPHORUS *of* KUNCKEL, *and* SALT (FUSIBLE) *of* URINE.

*Alkalis* or *saline alkaline substances* are,

*The fixed alkali of common salt*, called also *mineral* or *fossil alkali*, *marine alkali*, *crystals and salt of soda*, because it is obtained by lixiviation and crystallization from the ashes called *soda*.

*Vegetable*, or *common fixed alkali*. It is often called salt of tartar, or alkali of tartar, in the works of chemists, because the ashes of tartar furnish the largest quantity of it. Both these fixed alkalis are called *caustic fixed alkali*, when they have been altered by quicklime, or by metallic calxes. *See* ALKALI (FIXED).

*Volatile alkali*. That is called *fluor volatile alkali* which has been altered by quicklime, or by metallic calxes, so that it afterwards cannot be obtained in a solid or concrete form. *See* ALKALI (VOLATILE).

## NEUTRAL SALTS.

Formerly those only were called neutral salts which were composed of acids and alkalis united together to the point of saturation, so that they had no acid or alkaline property, and thence they were called neutral. But now this name is commonly extended to combinations of acids with all substances with which they can so unite, that they lose entirely, or mostly, their acid qualities, as, for instance, when they are united with earthy or metallic substances. We shall enumerate these neutral salts, observing the order of the acids already enumerated.

VITRIOLIC

## NITROUS SALTS.

Nitrous acid, combined with all the substances of which we have just mentioned the combinations with vitriolic acid, forms salts to which we may give the general names of *nitre* or *nitrous salt*, specifying each salt by the name of the substance united with the acid.

Nitrous acid with fixed vegetable alkali forms *ordinary nitre*, or *saltpetre*.

With marine alkali it forms *cubic* or *quadrangular nitre*.

With volatile alkali, *nitrous ammoniacal salt*, or *ammoniacal nitre*.

With calcareous earths, *nitre with basis of calcareous earth*.

With argillaceous earths, *nitre with basis of argillaceous earth*, a kind of *nitrous alum* little known.

With metallic substances, *metallic nitres*.

With gold, *nitre of gold*, unknown.

With silver, *nitre of silver*, *lunar nitre*, *lunar crystals*, or *crystals of silver*.

With copper, *nitre of copper*, or *cupreous nitre*.

With iron, *nitre of iron*, or *martial nitre*.

With tin, *nitre of tin*, unknown.

With lead, *nitre of lead*, or *crystals of lead*.

With mercury, *nitre of mercury*, *mercurial nitre*, *crystals of mercury*.

With regulus of antimony, *nitre of antimony*, unknown.

With bismuth, *nitre of bismuth*, *crystals of bismuth*.

With zinc, its calx and flowers, *nitre of zinc*, unknown.

With regulus of cobalt, *nitre of cobalt*, not much known. Mr. Beaumé has begun to examine it.

With arsenic and its regulus, *nitre of arsenic*, or *arsenical nitre*, very little known. *See* NITRES (METALLIC), *or with* METALLIC BASES. *See also the articles* ACID (NITROUS), *the articles of all the substances we have mentioned, and those of the nitrous salts which have particular names.*

## MARINE SALTS, *or simply*, SALTS.

Marine acid forms with all these substances salts which may be called by the general name of *marine salts*, or simply *salts*, and specified by the names of their particular bases. Thus,

With marine alkali, it forms *common salt*, *kitchen salt*, *sea-salt*, when extracted from the sea, and *sal gem* when dug from the earth.

## VITRIOLIC SALTS.

Vitriolic acid combined with marine alkali forms known by the name of *Glauber's ſalt*, or *ſal mirabile*

With fixed vegetable alkali it forms a ſalt called *[illegible] tartar*, *ſal de duobus*, and *arcanum duplicatum*. [illegible]

With volatile alkali, it forms an ammoniacal ſal *vitriolic ammoniacal ſalt*, and *ſecret ſal ammoniac of* See AMMONIAC (SALT).

With calcareous earths, it forms *vitriolic ſalts of calcareous earth*, known by the general name See that word.

With argillaceous earths, it forms a vitriolic ſ of argillaceous earth, called *alum*. See ALUM.

With metallic ſubſtances, it forms different [illegible] metallic [illegible], to which we ought to giv name of [illegible], together with the name of t metal [illegible]

With gold, a ſalt little or not known, called *[illegible] of gold*.

With ſilver, a ſalt but little known, [illegible]

With copper, a ſalt known by the name [illegible] *blue* [illegible]

[illegible] more general [illegible]

According [illegible]

[illegible]

The [illegible]

[illegible]

With [illegible] a ſalt little known.

With [illegible] known, a [illegible]

With [illegible] mercury, a ſalt [illegible]

With regulus of antimony, a ſalt [illegible]

With [illegible] little known,

With [illegible]

known by the name of [illegible]

[illegible]

## NITROUS SALTS.

combined with all the substances of which
combined the combinations with vitriolic acid,
we may give the general names of nitro
giving each salt by the name of the lik
vegetable alkali forms ordinary
ic or quadrangular nitre,
ammoniacal salts, or ammoniacal
nitrous salts of calcareous earth,
with bases of argillaceous
little known.
earth.
earth, lunar crystals, or
nitrous nitre.
nitre.
of lead.
al nitre, crystals of
or cinnabar
much.
much cinnabar

SALTS.

combination
getable acids

of the a
analogous

With fixed vegetable alkali, *common salt with basis of vegetable alkali*, called *febrifugal salt of Sylvius* improperly, because it is no more febrifugal than any other; and still more improperly called *regenerated sea-salt*, because it differs essentially from sea-salt by the nature of its basis.

With volatile alkali, it forms *sal ammoniac*, formerly *armoniac*, and by some chemists called *salmiac*.

With calcareous earths, a *salt with basis of calcareous earth*. As this salt is obtained in the decomposition of sal ammoniac by means of quicklime, or other calcareous earths, chemists have improperly called the salt made in this manner *fixed ammoniac*, when it is dry; and *oil of lime*, when it is liquid.

With argillaceous earths, it forms a *salt with basis of argillaceous earth*, very little or not known.

With metallic substances, it forms *salts with metallic bases*, specified by the name of each base. Thus,

With gold, it forms a *salt of gold*, unknown.

With silver, it forms a *salt of silver*, known by the name of *luna cornea*.

With copper, it forms a *salt of copper*, not much examined.

With iron, a *salt of iron*, or *martial salt*, not much examined.

With tin, a *salt of tin*. This combination, like those of the marine acid with metallic matters, may be made by dissolving immediately the metal in the acid: but it may be still better made by decomposing, with the assistance of heat, and by means of the metal intended to be united with the marine acid, a combination already made of this acid with some other metallic substance; which is always possible when the affinity of the metal to be combined is greater than that of the metal already combined. Thus we may form easily a crystallizable salt of tin, by dissolving this metal directly in marine acid in the usual manner: this salt is but little known. The same combination is made by decomposing corrosive sublimate by means of tin, and by distillation. Thus we may obtain a combination of tin with marine acid, one part of which passes with excess of acid in form of a very smoking liquor, called *smoking spirit of Libavius*; and the other part which does not smoke, and which contains a larger proportion of tin, is sublimed in a solid state, and is called *butter of tin*.

With lead, *salt of lead*, known also by the name *plumbum cornuum*.

With

With mercury, *salt of mercury*. It has different names according to the manner of making it, and according to the proportions of marine acid and mercury. It is called *white precipitate*, when it is separated from the nitrous acid by means of marine acid; *mercury corrosive sublimate*, or simply, *corrosive sublimate*, when it is actually sublimed, and with such proportions of mercury and acid, that a very corrosive salt results from them; *sweet mercury*, *sweet sublimate*, and *aquila alba*, when sublimed with an additional quantity of mercury by which its corrosive quality is blunted.

With regulus of antimony, it forms an *antimonial salt* by distillation. It is called *butter of antimony*.

With bismuth, it forms a *salt of bismuth*, not much examined.

With zinc, and its calx and flowers, a *salt of zinc*, little known.

With regulus of cobalt, a *salt of cobalt*, also little known.

With arsenic and its regulus, a *salt of arsenic*, or *butter of arsenic*, little known.

We may observe concerning all these combinations of marine acid with metallic matters, that, as this acid is very volatile, and as it is capable of adhering strongly with these substances, it does accordingly carry along with it more or less of them in sublimations and distillations; which is the reason that these salts are variable, as to the proportions of acid and metal which unite together, or which remain united, either directly by solution, or by distillation and sublimation, as we see from the phenomena exhibited by corneous metals, as tin and regulus of antimony. Although chemists, and still more, alchemists, have operated much on certain combinations of metallic substances with marine acid, much yet remains to be done to illustrate this subject.

We may here observe, that aqua regia, composed of nitrous and marine acids, which is in general a great solvent of metallic matters, must form with many of them mixed salts, some of which are perhaps of peculiar natures: but these combinations do not seem to have been examined hitherto as salts, no more than many others, as we may easily see from the present enumeration. *See the articles* ACID (MARINE), *and of the several substances with which we have mentioned its combinations.*

## TARTAREOUS SALTS.

We shall give this name to the combinations of the acid of tartar, or of other concrete vegetable acids analogous to

it, with the several substances capable of uniting with these acids. But very few of these salts are known, which are in general called *soluble tartars*, because they are all more soluble in water than the acid of tartar itself.

The combination of cream of tartar with fixed vegetable alkali forms a neutral crystallizable salt, called *soluble tartar*, *tartarised tartar*, and *vegetable salt*. *See this latter word.*

With marine alkali, it forms the salt known by the name of *salt of Saignette*, *sal polychrest*, *salt of Rochelle*.

With volatile alkali, a *soluble ammoniac tartar*, unknown.

With calcareous earths, *soluble tartars with basis of calcareous earth*, very little known, but which appear similar to the *soluble tartars with basis of fixed alkali*.

With argillaceous earths, *soluble tartars with basis of argillaceous earth*, unknown.

With metals, *soluble tartars with metallic bases*, *soluble tartars of gold*, *of silver*, &c. which are all unknown, excepting the soluble tartars with basis of *iron* and of *glass of antimony*. The former is deliquescent, and called, when liquid, *tartarised tincture of iron*, or *of Mars*; and when evaporated, *martial extract*. It ought to be called *soluble martial tartar*. *See* TARTAR (SOLUBLE), *and the other names here mentioned.* The second soluble tartar with metallic basis is called *emetic* or *stibiated tartar*. *See* TARTAR (EMETIC).

## ACETOUS SALTS.

We shall give this name to all salts containing the acid of vinegar.

With fixed vegetable alkali, it forms a *deliquescent salt*, called improperly *terra foliata tartari*, and *regenerated tartar*.

With marine alkali, it forms a crystallizable salt not much known, to which no name has been given. It may be called *acetous salt with basis of marine alkali*.

With volatile alkali, an *acetous ammoniacal salt*, imperfectly known, and named *spirit of Mindererus*.

With calcareous earths, several *acetous salts with calcareous bases*, very similar one to another, and susceptible of crystallizing, and forming beautiful *silky vegetations*, some of which are superficially known, and named *salts of chalk*, *of crab's eyes*, *of coral*, &c.

With argillaceous earths, *an acetous argillaceous salt*, unknown.

With metallic substances, an *acetous salt with metallic basis*, *of gold*, *silver*, &c. which are all unknown, excepting the three following:

With

With copper, an *acetous salt of copper*, known in chemistry by the names, *crystals of Venus*, or *of Verdigrise*, and in commerce and arts by the name *distilled*, or *crystallized verdigrise*.

With lead, an *acetous salt of lead*, known by the name of *salt*, or *sugar of lead*.

With mercury, an *acetous mercurial salt*, lately so named, but little known.

## VEGETABLE SALTS.

This general name may be given to all neutral salts composed of the *acid juices*, *concrete salts*, *natural* or *unfermented acids of vegetables*, with the several substances capable of uniting with these acids; but none of these salts are yet known.

## VEGETABLE EMPYREUMATIC SALTS.

Neither do we know any thing of the salts which might be formed with the acids obtained by the distillation of vegetable matters, which furnish acid spirits or concrete acids, and which might be called *vegetable empyreumatic salts*.

## ANIMAL EMPYREUMATIC SALTS.

By this name we may distinguish neutral salts composed with acids obtained from the distillation of animal matters, as the *acids of insects*, *of butter*, and *of fat*; but all these salts are perfectly unknown.

Although we have given the epithet *empyreumatic* to salts formed with vegetable and animal acids, obtained by distillation of these substances with a heat greater than that of boiling water, we do not mean to imply, that these salts, if they were well made and purified, would retain an empyreumatic character, or any part of the burnt oil which adheres to these acids after distillation. On the contrary, these acids may be deprived entirely or partly of this oil by passing into combinations of neutral salts, as happens to volatile alkalis when transformed into ammoniacal salts: but in this case we should be better able to examine the nature of these acids, and the epithet empyreumatic would only refer to the manner of obtaining them, and would serve to distinguish them from those vegetable or animal salts, the acids of which have been obtained without distillation in a naked fire.

## PHOSPHORIC SALTS.

By this general name we mean all ſalts produced by combining the acid of *phoſphorus of urine* with alkaline, earthy, and metallic ſubſtances, a ſmall part of which ſalts is known even imperfectly.

With fixed vegetable alkali, this acid forms a *phoſphoric ſalt*, a kind of *fuſible ſalt of urine.*

With marine alkali, it forms another *phoſphoric ſalt*, or *fuſible ſalt of urine with baſis of marine alkali.* It is not known.

With volatile alkali, a *phoſphoric ammoniacal ſalt*, called alſo *fuſible ſalt of urine*, *native ſalt of urine*, *microcoſmic ſalt.*

With calcareous and argillaceous earths, *phoſphoric*, *calcareous*, *and argillaceous ſalts*, not known.

With metallic ſubſtances, *phoſphoric metallic ſalts of gold*, *ſilver*, *copper*, &c. very little known. *See the article* PHOSPHORUS.

Beſides the ſaline ſubſtances which have ſenſible acid properties, ſome ſubſtances, as ſedative ſalt and arſenic, without having theſe properties, do nevertheleſs act as acids in their combinations with all ſubſtances capable of uniting with true acids, of forming with theſe ſubſtances kinds of neutral ſalts, and even of communicating, like the acids properly ſo called, ſaline properties to thoſe ſubſtances which have them not. Theſe combinations are by general conſent claſſed amongſt neutral ſalts.

## BORAX, *or* SALTS *of* BORAX.

The ſedative ſalt, combined with marine alkali, forms *ordinary borax.*

With fixed vegetable alkali, a kind of *borax*, not much known.

With volatile alkali, an *ammoniacal borax*, not much known.

With calcareous and argillaceous earths, *calcareous* and *argillaceous borax*, unknown.

With metals, *borax with metallic baſes of gold*, *ſilver*, &c. unknown.

## ARSENICAL SALTS.

Arſenic forms, with fixed vegetable alkali, a neutral ſalt perfectly ſoluble in water, and cryſtallizable, called by Mr. Macquer,

Macquer, who first observed it, *neutral arsenical salt*, or simply *arsenical salt*. *See* ARSENIC, *and* SALT (NEUTRAL ARSENICAL).

With marine alkali, another arsenical salt, very like the former, but not much examined.

With volatile alkali, an *arsenical ammoniacal salt*, unknown.

With calcareous and argillaceous earths, a *calcareous* or *argillaceous arsenical salt*, unknown.

With metallic substances, arsenic is perhaps capable of forming *arsenical salts with metallic bases*, or combinations in which saline properties would be perceptible, if these combinations were made by decomposing nitrous salts with metallic bases by means of arsenic, or by precipitating metals dissolved in acids by means of a solution of neutral arsenical salt in water; but perhaps from thence nothing would be produced but combinations similar to the arsenical minerals. We are quite ignorant upon this subject.

Saline alkaline substances, besides the salts which they can form with acids, can also act upon earths and metals, with which they form saline compounds, and from which, when separated, they appear as before. Accordingly, these compounds may for this reason be ranked amongst salts, and general and particular denominations may be assigned to them, according to the principles which compose them, as, for example, *alkaline earthy salts*, *calcareous*, *argiliaceous*, *vitreous*, *metallic*, as of *gold*, *silver*, &c. But hitherto chemists have not considered them in this view, and have even examined them but little.

Lastly, acids, alkalis, and even several neutral salts may, by combining with oily substances, form compounds which may be considered as true salts, if this name be given, as it ought to be, to every thing that is sapid and soluble in water; but these compounds form in some measure a distinct class, and are distinguished by the name of *soap*. *See* SOAP.

From this enumeration of saline compounds we may see how many of them are little known, or not even thought of. The numerous experiments yet to be made in this extensive part of chemistry are nevertheless very necessary, and are fundamental and elementary. To make them successfully, nothing is requisite but accuracy, patience, and knowledge of the first principles of chemistry. Every intelligent person is capable of making them. For this purpose the acids, alkalis, earths and metals employed must be very pure, the saline compounds resulting from their union

muſt be examined; their taſte, ſolubility in water, cryſtallization, deliqueſcence, and the methods of decompoſing them muſt be obſerved. Theſe conſiderations are certainly ſufficient to excite the zeal of perſons who would contribute to the progreſs of chemiſtry.

We now proceed to treat ſummarily of the principal ſalts known by the name of ſalts, in an alphabetical order.

## ACID SALTS.

Some chemiſts, and particularly ancient chemiſts, have thus named the ſaline ſubſtances which we only call *acids*. *See* ACIDS. We may however continue this name, and apply it to ſome concrete ſaline ſubſtances, as *tartar*, ſalt of *ſorrel*, &c. and to ſeveral other eſſential ſalts, which ſeem to be intermediate betwixt the ſtate of pure acids and of neutral ſalts.

## SALTS *with* BASES ALKALINE, EARTHY *and* METALLIC.

By theſe general denominations the ſeveral neutral ſalts are diſtinguiſhed according to the nature of the baſis, or ſubſtance with which the acid is combined. *See the above enumeration of ſalts. See alſo the article* NEUTRAL SALTS.

## SALT ALEMBROTH.

This is a ſaline matter, compoſed of *corroſive ſublimate* and of *ſal ammoniac*, mixed in equal parts, or in other different proportions, which the ancient chemiſts, eſpecially the alchemiſts, have much employed as a powerful ſolvent of metals, and even of gold. We are certain that corroſive ſublimate and ſal ammoniac act powerfully one upon another, and combine together without being decompoſed, from which is formed a ſaline compound of a ſingular nature, capable of acting very effectually upon metallic ſubſtances. But the alchemiſts, who made ſo much uſe of this famous ſolvent, were far from underſtanding clearly the operations in which they employed it. As alchemiſts loved pompous names, they called this compound *ſalt of art*, *ſalt of wiſdom*, *ſalt of ſcience*.

ALKALINE

## ALKALINE SALTS.

This name is frequently given to saline alkaline substances, as *fixed alkalis*, *vegetable* and *mineral*, *volatile alkali*. *See these words.*

## SALT *of* AMBER, *or* VOLATILE SALT *of* AMBER.

This is a saline, oily, concrete matter, obtained by sublimation, or even by crystallization, from amber. It is a kind of essential salt, which forms shining needle-like crystals, has the smell of rectified oil of amber, and is soluble in spirit of wine. It is used only medicinally, as an antispasmodic, with the same effect as the spirit and rectified oil of amber. *See* BITUMENS *and* SALTS (ESSENTIAL).

## AMMONIACAL SALTS.

By this name are distinguished all neutral salts composed of any acid saturated with volatile alkali. *See* AMMONIACAL SALTS; *and* SALTS (NEUTRAL).

## ARSENICAL SALTS.

*See* SALT (NEUTRAL ARSENICAL).

## COMMON SALT.

Common salt is a neutral perfect salt, composed of a peculiar acid and a peculiar alkali, which are called *marine acid*, and *marine* or *mineral alkali*.

This salt, which is produced by nature, is more abundantly and universally diffused than any other. Immense mines or quarries of it are found within the earth, and it is then called *sal gem* or *fossil salt*. The waters of all the sea, and many subterranean and mineral waters, contain it. From every vegetable or animal chemists can extract it.

The taste of common salt is agreeable and moderately strong. It is crystallizable, and is one of those the figure of whose crystals is most regular, most determinate, and least variable. The crystals of this salt are perfect, or nearly perfect cubes; for the hollow pyramids obtained in certain evaporations of salt waters are nothing but a heap of cubical crystals, arranged in this manner near each other, by means of evaporation.

Common salt is moderately soluble in water. Four parts of water are required to dissolve one part of salt; and hot or boiling water dissolves no more of it than cold water.

For

For which reason it is only obtainable from sea-water, and other waters impregnated with it, by a continued evaporation. *See* CRYSTALLIZATION.

Although common salt be very crystallizable, and exactly neutral, it very readily becomes moist when exposed to humid air. It must be preserved in very dry places.

This salt is susceptible of contracting a certain union with *common salt with calcareous basis*; for which reason all the salt obtained either from sea-water or salt fountains always contains a certain quantity of this salt with earthy basis. Thus, if any common salt be dissolved in very pure water, and fixed alkali be added to this solution, we soon see the white earth of the salt with earthy basis which is precipitated. As therefore crystallization seems insufficient for the purification of common salt from the salt with earthy basis, when we would obtain a very pure common salt, as is necessary for some delicate operations, we must dissolve it in water, filtrate it, and add to it a solution of crystals of soda, or marine alkali, till no more white cloud is formed by the addition; then filtrate again the liquor, and evaporate. By this method we shall obtain a common salt perfectly pure. *(b)*

Common salt, exposed to the action of fire, crackles and decrepitates pretty strongly, when heated to a certain degree, especially if it be heated hastily. Its crystals burst into small pieces during this decrepitation. This effect is produced by the water of the crystallization of the salt, which being confined by the parts of the salt, and at the same time reduced into vapors by the action of fire, bursts the parts of the salt, and is dissipated. Many chemists consider this decrepitation of common salt as a pro-

*(b)* Sea-water contains dissolved in it not only sea-salt, or a combination of marine acid with mineral alkali, but also other salts, especially combinations of marine and vitriolic acids with the earth called magnesia, which is not calcareous. *See* MAGNESIA, *and the Note subjoined.* Some of these salts, with basis of magnesia, are crystallized along with the sea-salt by the evaporation of the sea-water, and part of them remains in the residuous liquor called the mother-water. Some portion of true calcareous earth, dissolved by marine and vitriolic acids, is said also to be contained in sea-water; but the quantity of this is very small in comparison of the quantity of magnesia; to the precipitation of which, therefore, the cloud or turbid appearance given to sea-water, or to a solution of common salt in water, is chiefly owing.

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perty peculiar to it, and by which it may be known; but vitriolated tartar, nitre of lead, and probably many other ſalts, are ſuſceptible of a ſimilar decrepitation.

If ſalt be expoſed to a red-heat after this decrepitation, it fuſes; and when afterwards cooled, it fixes in form of a white and almoſt opake maſs; but excepting that it has loſt the water of its cryſtallization, it is the ſame as before this expoſure to fire.

Several chemiſts, having obſerved that when common ſalt is heated in a retort a little marine acid exhales from it while it contains any moiſture, and that by adding more moiſture more acid may be thus obtained, have believed that, by means of water, all its acid may be expelled from it. But they have been deceived; for this ſmall quantity of acid obtained by repeated humectations and diſtillations proceeded only from the common ſalt with earthy baſis, which, we have obſerved, is always mixed with common ſalt. From this earthy ſalt a proportion of acid may actually be obtained by this method: but M. Beaumé has found, that no acid can be thus expelled from common ſalt perfectly purified in the above-mentioned manner.

This ſalt is abſolutely unalterable by fire, even when it has been heated ſtrongly, together with inflammable matters. The unalterable property of common ſalt by fire proceeds from the ſmall diſpoſition which its acid has to combine with phlogiſton. This truth has been demonſtrated by the experiments of Mr. Duhamel and of Mr. Margraaf.

Although this ſalt be fixed in the fire to a certain degree, yet when it is expoſed to a violent fire with free acceſs of air, it exhales in vapors, and attaches itſelf in white flowers to bodies which it finds leſs hot than itſelf. We have examples of this effect in certain fuſions of ores, where common ſalt is added; and in glaſs-houſe furnaces, where this ſalt, of which a certain quantity is contained in ſoda and potaſh, and which cannot enter into vitrification, attaches itſelf to the ſides of the openings or holes.

We know no other acid but vitriolic and nitrous acids, and ſedative ſalt, which can decompoſe common ſalt by diſengaging its acid; for arſenic, which ſo eaſily and effectually decompoſes nitre, cannot act upon this ſalt; a phenomenon, the cauſe of which deſerves to be examined, and which is certainly connected with an important theory.

Common ſalt is of all ſaline ſubſtances the moſt neceſſary, and extenſively uſeful. Beſides the particular uſes of its acid and alkali in many chemical operations and in arts;

besides its great utility in the fusion of glass, which it whitens and purifies, although it does not enter, and perhaps because it does enter into their combination, as Mr. d'Antic has shewn; and from the property it has of facilitating the fusion and precipitation of the metallic parts of minerals in essays, and of covering them perfectly; besides these, I say, its great use in aliments, the taste of which it improves by its agreeable piquancy, when mixed in proper quantity, is universally known. But this is not the only advantage; for it retards and prevents the putrefaction of almost all our aliments, without producing any such change upon them, even when preserved a long time by means of it, as to render them unfit for the purpose of nourishment. All other saline matters may indeed preserve from putrefaction, as common salt does, and some of them even more effectually: but we do not know any other, the taste of which renders it capable of being substituted to common salt for this purpose.

A very remarkable circumstance in the antiseptic property of common salt, and of some other salts, is, that this property varies surprisingly according to the proportions in which the salt is employed: for this salt, mixed with animal matters in a large proportion, preserves them from putrefaction, which it accelerates considerably when a small quantity only of it is employed. This singular fact is proved by the experiments of Messrs. Pringle and Macbride, and particularly by those of the accurate and intelligent author of *an Essay towards a History of Putrefaction*, Mr. Gardane, Physician of the Faculty of Paris, who, having convinced himself of this fact by his own experiments, mentioned it in a very good thesis, and has drawn from it a conclusion which seems to me very just, namely, that small quantities of common salt, such as those taken with aliments, facilitate digestion, which he considers as a beginning putrefaction. If this opinion be as true as it is probable and consistent with the principles of chemistry, and of the animal economy, then common salt is not only agreeable and useful, but also salutary, at least to all constitutions in which the digestion is too remote from putrefaction, as in those which are properly called *crudities*: for we cannot but agree, that different temperaments differ much in this respect. *See the articles* ACID (MARINE), ALKALI (MINERAL), CRYSTALLIZATION, WATER (SEA), WATER *of* SALT FOUNTAINS, SALTS, *and* SALTS (NEUTRAL).

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## CRYSTALLIZABLE SALTS.

By this name we distinguish all saline matters susceptible of crystallization. It is contrary to that of *fluor salts*, by which are distinguished saline substances that cannot be obtained in a crystallized concrete form, such as nitrous and marine acids, volatile alkali altered by quicklime, and some others. We have nevertheless reason to believe, that, rigorously speaking, every saline substance is essentially susceptible of crystallization, and that in this respect they only differ in the degree of facility with which they may be crystallized; for we are certain that many very deliquescent salts, the crystallization of which has not, that I know of, been ever observed, such as *common salt with calcareous basis*, may nevertheless assume solid regular forms by the cooling of their solutions when very much concentrated. Mr. Beaumé has observed the crystallization of this and several similar salts. *See* CRYSTALLIZATION, DELIQUESCENCE, SALT, *and* SALTS (NEUTRAL).

## SALTS *of* CENTAURY, *of* WORMWOOD, *of* SORREL, &c.

The name of *salt*, added to the proper name of some substance, is applied to very different matters. It is given, for example, to all the fixed alkalis obtained from the ashes of vegetable matters. Salts of wormwood, centaury, &c. are saline matters obtained by lixiviating the ashes of these plants: but these names are improper in several respects; for if we apply them to the fixed alkalis of plants, as they do not differ from each other, it is useless to distinguish them by the name of the plant from which they are obtained; and even when they are prepared in Tachenius's method, although they differ a little, yet their character of fixed alkali is so predominant, that no name ought to be given to them but what has a relation to that character. Accordingly, the names *salt of tartar*, *salt of soda*, which are frequently given to the alkalis of these substances, are for the same reason very improper. They ought to be called *alkali of tartar* and *alkali of soda*.

Certain concrete acids, as the essential salt of sorrel, tartar &c. are also simply called *salt of sorrel*, &c. This is also faulty, because these names do not denote the nature of the saline matters, and may be the occasion of confounding them with other salts of a very different nature. They ought

ought to be named *essential salts*, or rather *concrete acids of sorrel, of tartar*, &c.

The names *salts of coral, of pearls, of crabs eyes*, are not more accurate, unless we add the epithet *acetous*, as *acetous salt of coral*, &c. for these substances may be combined, and may form salts with any other acid, as well as with vinegar.

Let us now judge if the names, *salt of quinquina, of sena, of onions*, &c. given to the dry extracts of these matters made in the manner of the Count de la Garaye, are not entirely improper. *See the preceding enumeration of salts.*

## SALT *of* COLCOTHAR.

This is a white saline matter, obtained by lixiviating colcothar. This matter is not much used, and has not been much examined. It is probably some *selenitic* or *aluminous* substance, which is mixed with the vitriol, and which was contained in the pyrites from which the vitriol was extracted.

## SAL DE DUOBUS.

It is a neutral salt, formed by saturating vitriolic acid with the alkali of nitre. *See* TARTAR (VITRIOLATED).

## DELIQUESCENT SALTS.

Thus are named all saline matters which may be obtained by crystallization or drying in a concrete form, but which, when exposed to air, imbibe its moisture, and lose their concrete crystallized form, deliquiating into a liquor by means of this moisture. *See* DELIQUESCENCE.

## SALTS *of* ENGLAND, *of* EPSOM, *of* SEDLITZ.

Some saline substances have been denominated from the countries where they have been first discovered. Thus a very rectified concrete volatile alkali, obtained from silk, is called *salt of England*; and even some druggists give this name to the concrete volatile alkali obtained from sal ammoniac.

In a similar manner, the name of Epsom salt is given to a badly crystallized, bitter Glauber's salt, which easily becomes moist because it is mixed with common salt, and common salt with calcareous basis. It was first obtained from a salt well at Epsom, near London. This name has been since given to a similar

-'s salt obtained from salt marshes in France, ue and pure Glauber's salt obtained from the . salt-works of Lorraine and Franche-Compté, ization of which they disturb purposely to prevent resembling entirely the pure salt of Glauber. *See a to the Article* GLAUBER'S SALT.

*Salt of Sedlitz* is also a Glauber's salt under another name; and perhaps the same may be said of many other salts denominated from places.

## ESSENTIAL SALTS.

This name is given to all concrete saline matters which preserve the smell, taste, and all other principal qualities of bodies from which they were obtained, which bodies are only vegetable and animal. The usual method of preparing them is by evaporating, to almost the consistence of a syrup, the liquors containing the essential salt, namely, the expressed and depurated juices and strong decoctions, and by keeping them in a cold place. From many of these liquors, saline matters or crystals are deposited upon the sides of the containing vessels after a considerable time, and after they have undergone a kind of fermentation. These crystals, which are always very red, may be purified by dissolving them in water, filtrating, evaporating, and crystallizing.

We may observe, that the salts thus obtained from animal and vegetable matters are sometimes nothing but vitriolated tartar, Glauber's salt, nitre, common salt, and other such neutral salts, which ought not to be considered as the essential salts of the substances from which they are extracted.

These mineral salts are extraneous to the vegetables and animals from which they are obtained. They are not parts of those substances, nor are combined with them; and when they are purified from the extractive matter with which they are at first only mixed and covered over, they have then nothing vegetable or animal. These salts are introduced into vegetables and animals along with aliments, are mixed in their liquors and circulate in their vessels, but receive no alteration, nor contract any true union with the proximate principles of animals and vegetables, because they are naturally incapable of such union.

The proof of this truth is, that they are always obtained from vegetables and animals in the same state in which they were introduced, and that their quantity in these substances is altogether inconstant and variable, without any real difference

difference being produced in the vegetables or animals by this variation of the quantity of these salts. Certain plants, as the *parietaria*, but still more the *corona solis*, have the property of imbibing so much nitre, that, when they grow in nitrous soils, they are almost filled with this salt. I have seen the dried pith of corona solis so full of crystallized nitre, that when shook over a paper, a considerable quantity of good deflagrating nitre might be collected. But we know also that this plant, when cultivated in a less nitrous soil, does not contain nearly the same quantity of nitre, although it be otherwise in good condition. These mineral salts therefore must not be considered as the essential salts of plants or animals; and only those salts are to be considered as such, in the combination of which we find oily parts, which cannot be separated from them, unless the salt be decomposed.

In the second place we shall observe, concerning salts truly called essential, that but very few of them are yet known, and most of these but very imperfectly. Of all these essential salts the best known is tartar, the properties of which may be seen under the article TARTAR. The druggists have a very white concrete salt, well crystallized, and soluble in water, which they call *salt of sorrel*. We may indeed obtain from the juice of sorrel, by the above-mentioned process, an essential acid concrete salt, but much more earthy and less acid than the salt above-mentioned. Besides, Mr. Beaumé, who has made some inquiries into this matter, affirms, that a true salt of sorrel could not be procured at the price of the salt which is commonly sold under that name, the quantity of salt obtainable from sorrel being very small. The salt above-mentioned is brought from Germany, is much more acid and more soluble in water than cream of tartar; it acts upon all substances soluble by acids; but the neutral salts thence formed have not been examined.

*Flowers of benjamin*, *volatile salt of amber*, and other saline matters of the same kind, seem to belong to this class of essential salts; but they are little known. Essential salts may be considered as a new subject of inquiry.

## FIXED SALTS.

Many chemists give this name to the salts obtained from the ashes of plants, which not having been dissipated by fire, ought to be considered as fixed, in comparison of the other saline

ſaline matters of theſe plants, which evaporate during their deflagration.

As the ſaline ſubſtances remaining in the aſhes of vegetables are entirely or chiefly alkaline, the name of *fixed ſalt* has become ſynonimous with that of *fixed alkali*. But other ſaline ſubſtances, as moſt neutral ſalts, which have not baſes of volatile alkali, are nearly as fixed as fixed alkali.

The fixity of any ſaline matter is not perfect; ſince any of them by a long-continued violent fire may be altogether evaporated. A proof of this we find in glaſs-houſes. A part of the fixed alkali, of the common ſalt, of Glauber's ſalt, of vitriolated tartar, and other equally fixed ſalts, contained in the aſhes uſed in the compoſition of glaſs, are perpetually exhaling, during the fuſion of glaſs, in a vapor which may be ſeen above the pots; and this vapor forms ſaline incruſtations round the openings and other leaſt hot places of the furnace. Accordingly, the quantity of ſalt of glaſs which covers the ſurface of the melted glaſs is continually diminiſhing. I have had occaſion to take from a vitrifying furnace, at different times, eighty crucibles, containing all the ſame compoſition for cryſtal-glaſs, of which ſoda and pot-aſh made parts. The crucibles firſt taken out were covered with a cruſt of ſalt of glaſs more than two lines thick; thoſe taken out 18 or 20 hours afterwards had only a very thin ſtratum of glaſs-gall; and, laſtly, the crucibles which remained 72 hours in the fire, had no ſalt, or only a very ſmall quantity, upon the middle of the ſurface of glaſs.

Hence we ought to conclude, that the quality of fixity aſcribed to ſome ſalts is only relative. We conſider thoſe as fixed which ſuſtain a red heat during ſeveral hours, without any ſenſible diminution. Salts which by a red heat are reduced into vapors and ſublimed, are called *ſemi-volatile*, as the ammoniacal ſalts, and corroſive ſublimate; and laſtly, ſalts which are diſſipated without heat, or with very little heat, as the volatile acids and alkalis, are called *volatile ſalts*.

## FLUOR SALTS.

This name is given to all ſaline ſubſtances which cannot by any method be rendered ſolid; ſuch are nitrous and marine acids, volatile alkali altered by quicklime, and ſome others. This quality depends on their volatility, and on the affinity which they have with water ſuperabundant

to their ſaline eſſence. In this latter point they reſemble deliqueſcent ſalts, and they may even be conſidered as ſalts perpetually and unſurmountably deliqueſcent. But they differ from ſalts that are only deliqueſcent, in this circumſtance, that theſe latter are much leſs volatile than the fluor ſalts, and can ſupport a heat ſufficient to deprive them of all their ſuperabundant water, and to reduce them to a concrete form. *See* DELIQUESCENCE *and* SALT.

## FUSIBLE SALT *of* URINE.

This ſalt, called alſo *native* or *eſſential ſalt of urine*, *phoſphoric ſalt*, *microcoſmic ſalt*, is a neutral ſalt compoſed of an acid named *phoſphoric*, ſaturated with an alkali fixed or volatile; for both theſe kinds of alkalis ſeem to be contained in urine.

To obtain this ſalt, urine freſh or putrid is to be evaporated to the conſiſtence of a ſyrup, ſlowly or quickly. This urine, which is then very red, or brown, is to be put in a cold place. The fuſible ſalt cryſtallizes on the ſides of the veſſel. When the ſalt ceaſes to form itſelf on the veſſel, the liquor is to be decanted, and again evaporated, that ſtill more cryſtals may be obtained by the ſame method. Theſe cryſtals are to be collected, which are very dirty and brown. They may be purified by diſſolving in pure water, filtrating, evaporating, and cryſtallizing, according to the general method. Theſe operations ought to be repeated when the ſalt is required to be very white and pure. Thus they are diſengaged not only from the extractive part of the urine which diſcolors them, but alſo from a portion of common ſalt which may be mixed with them, particularly when the urine has been much evaporated.

This ſalt is very ſuſceptible of cryſtallization, and is one of thoſe which are more apt to cryſtallize by cold, than by evaporation.

If this ſalt be expoſed to the action of fire in cloſe veſſels, a very pungent volatile alkali is expelled from it, which Mr. Schloſſer has obſerved to be always fluor, like that which has been altered by quicklime. This chemiſt affirms even that if concrete volatile alkali be combined with the fuſible ſalt of urine, and ſeparated from this ſalt by diſtillation, it will be in a fluor ſtate.

The acid of this ſalt is fixed, and remains at the bottom of the veſſels, melted to a vitreous matter, if the heat has been

been sufficient for that purpose. This is the acid which produces the phosphorus of Kunckel, by its combination with the inflammable principle, and which gives the characteristic properties to the fusible salt of urine. *See the properties of this acid under the article* PHOSPHORUS *of* KUNCKEL.

If this fusible salt be mixed with the other fusible salt with basis of fixed alkali, as this latter salt cannot be decomposed merely by distillation, nor even by means of phlogiston, phosphorus is therefore chiefly produced from the former, or the ammoniacal fusible salt. *See* PHOSPHORUS *and* URINE. *(r)*

## FOSSIL SALTS.

Thus are called all the salts obtained ready formed within the earth; but more particularly common salt, which is coagulated in large masses within the earth, more frequently called *sal gem*.

## SAL GEM.

Sal gem is fossil common salt, or which is found within the earth in large masses: It has some transparency, by which it resembles crystal a little; and hence it has been called sal gem. The most considerable mines of this salt are in Poland. Very curious and interesting particulars

*(r)* Mr. Pott says, that the figure of fusible salts varies much according to the heat, evaporation, and different mode of crystallization; and that it assumes the shape of most others, as of saltpetre, vitriol, sal ammoniac, Glauber's salt, &c. but that it is generally in shining, octogonal, prismatic crystals. The taste of this salt is cool, not unlike that of borax, to which it is in other respects very similar. When put on the fire in a crucible, it froths, swells and melts. When melted upon a bit of charcoal by means of a blow-pipe, it forms a round drop.

The crystals of the second crystallization do also melt upon charcoal, when they are pure, but when cold they have a milky color. They do not, like the crystals of the first crystallization, form phosphorus with phlogiston. They effloresce in the air, and are hot to the taste, in both which instances they also differ from the first crystals. They have the properties of the Sal mirabile perlatum of M. Haupt.

These second crystals, which are a kind of Glauber's salt, are formed from the residuum of the crystallization of the fusible salt diluted with much water.

concerning these mines may be seen in a Memoir of Mr. Guettard, in the Memoirs of the Academy of Sciences.

## SALT *of* GLASS.

This matter, called also *glass-gall*, is a kind of saline scum or mass, found in glass-house pots upon the surface of the melted glass. It consists of neutral salts, as common salt, vitriolated tartar, and others which are contained in the soda and potash employed in the composition of glass, and which not being themselves susceptible of vitrification, are separated from the glass during the fusion, and are collected together upon its surface, because they are specifically lighter. Hence we see, that as all the soda and potash employed for the composition of glass contain more or less of these extraneous neutral salts, the salt of glass must vary according to the saline substances employed. For the same reason no salt of glass is found where only pure and vitrifiable salts, as purified alkalis, nitre, borax, &c. are employed. *See* VITRIFICATION.

## GLAUBER's SALT.

The salt thus named, from the chemist who discovered it, is a neutral salt, composed of vitriolic acid saturated with marine alkali.

Glauber discovered this salt, while he was decomposing common salt, by means of vitriolic acid, to obtain the smoking marine acid by distillation. The residuum of this distillation he found to be a saline mass, not crystallized, which he dissolved in water, and obtained, by evaporation and cold, transparent crystals. Glauber, surprised with the appearance and properties of these crystals, gave them the name of *sal mirabile*, by which they are still known, but more generally by that of *Glauber*'s salt.

This salt, although composed of vitriolic acid and a fixed alkali, as vitriolated tartar is, yet it differs from this latter salt in many respects; which differences are to be attributed to the difference of the alkaline bases, one being the vegetable fixed alkali, and the other the marine fixed alkali. The taste of Glauber's salt is saltish, but disagreeable and bitter. It is one of the salts which form the finest crystals. When large quantities of this salt are crystallized, and with due attention, large, oblong, columnar crystals are formed, the surfaces of which are striated longitudinally, like those of nitre.

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The cryſtals of this ſalt are as tranſparent as ice, but when expoſed to a dry air they loſe their tranſparency by the evaporation of the water of their cryſtallization. Their ſurface, and afterwards the whole of the ſaline maſs, is reduced by the diſſipation of this water to a white ſaline powder. This change alſo happens to the cryſtals of marine alkali, to which probably this property of Glauber's ſalt muſt be attributed.

The quantity of water which enters into the cryſtallization of Glauber's ſalt is very conſiderable, and amounts to nearly one-half of its weight. To this large quantity of water is probably owing the ſize and tranſparency of the cryſtals: for it ſeems to be a general rule, that the more water is contained in any ſalt, the more large and tranſparent its cryſtals are. From this ſame abundance of water, Glauber's ſalt liquefies with a heat quickly applied, till all the water be evaporated; and then it becomes dry and ſolid, and requires greater degree of heat to fuſe it.

This ſalt, although very ſoluble, even in cold water, is one of thoſe which may be diſſolved in a leſs quantity of boiling than of cold water. Hot water diſſolves nearly an equal weight of it. From this property we may know, that the cryſtallization of Glauber's ſalt is beſt procured by the cooling of a ſufficiently evaporated ſolution. Accordingly, a ſure method of obtaining the fineſt cryſtals of ſalt of Glauber is, to evaporate the water, in which it is diſſolved, till we find by taking out and trying a ſmall quantity of the ſolution while evaporating, that cryſtals are pretty quickly formed by cooling. It is then to be poured into flat and ſhallow veſſels, and cooled ſlowly. The larger the quantity of liquor is operated upon at a time, the larger will the cryſtals be; ſo that they may be obtained ſeveral feet long, and proportionably thick. Theſe cryſtals are placed horizontally upon each other, and the cryſtallization ought therefore to be performed in wide veſſels. *See* CRYSTALLIZATION.

Glauber's ſalt cannot be directly decompoſed but by means of phlogiſton only: for the decompoſitions made of it by metallic ſolutions are by means of a double affinity: and the decompoſition which may be effected by the nitrous acid alone, upon Glauber's ſalt and vitriolated tartar, as Mr. Beaumé diſcovered, is alſo cauſed by phlogiſton. *(s)*

*(s)* Concerning the decompoſition of Glauber's ſalt, and of vitriolated tartar by nitrous acid, *ſee the article* TARTAR (VITRIOLATED), *and the note ſubjoined.*

Glauber's ſalt is uſed only in Medicine. In ſmall doſes, as from one to two gros, it is reſolvent and aperitive, and as ſuch is added to ptiſans and apozems. It is alſo employed as an attenuant and corrective in the ſame doſe in purgative potions; and is itſelf a good and mild purgative, as all the neutral ſalts are, the baſis of which are fixed alkali: The doſe of this ſalt as a purgative is from an ounce to an ounce and a half.

To prepare Glauber's ſalt, we need not combine the pure diſengaged vitriolic acid with the alkali of ſoda, nor decompoſe common ſalt by vitriolic acid, as Glauber did, unleſs we deſire to obtain at the ſame time the marine acid. Nature furniſhes a large quantity of this ſalt already formed. A conſiderable quantity of it is contained in mineral waters, and perhaps all waters which contain common ſalt contain alſo ſome Glauber's ſalt. *(t)*. The ſalt wells of Lorraine, of Franche-Compte, of Epſom, contain much of it, and from theſe it may be eaſily obtained by cryſtallization. Further, from all vitriolic ſalts with earthy or metallic baſes, as ſelenites, alums, vitriols, Glauber's ſalt may be obtained by decompoſing them with ſoda. Laſtly, by burning ſulphur with common ſalt or ſoda, this ſalt may be formed. If it were much wanted, it might be eaſily and cheaply made by theſe proceſſes. *See the articles* ACID (VITRIOLIC), ALKALI (MARINE), CRYSTALLIZATION, WATER *of the* SEA, *and of* SALT FOUNTAINS, SALT, *and* NEUTRAL SALTS.

*(t)* Glauber's ſalt, that is, a ſalt formed by vitriolic acid combined with mineral alkali, is contained in ſea-water and in many mineral waters. But the *ſal catharticus amarus* of the London Diſpenſatory, extracted from the bitter liquor remaining after cryſtallization of ſea-ſalt in ſea water, and the *ſalt of Epſom*, and of moſt purging waters, tho' very ſimilar in appearance to the true Glauber's ſalt, with which it is frequently confounded, are found to be compoſed of vitriolic acid united with the earth called magneſia. *See* MAGNESIA. This ſalt conſiſts of priſmatic cryſtals like thoſe of Glauber's ſalt; has a bitter taſte; is ſoluble in leſs than an equal weight of water; when expoſed to a moderate heat, it quickly liquefies, and loſes the water of its cryſtallization, which amounts to more than half its weight; and is changed by this calcination into a white powder, almoſt totally ſoluble in water, by addition of which, together with evaporation, it may be reſtored to its former cryſtallized ſtate.

SALT

## SALT *of* LEAD.

This is commonly called the neutral ſalt compoſed of the acid of vinegar ſaturated with lead. As this ſalt has a ſweet and ſaccharine taſte, it is called *ſugar of lead.*

To make this acetous ſalt, ceruſs, which is lead half diſſolved, and corroded by vinegar, is to be entirely diſſolved in diſtilled vinegar by means of heat in a ſand-bath; the liquor, when perfectly ſaturated, is to be evaporated, and cryſtallized by cooling, and many ſmall needle-like cryſtals will be formed in it, which are to be well drained.

This ſalt is not much uſed in medicine. It is uſed only externally, becauſe the lead is pernicious. It is employed in ſome arts, and eſpecially in dyeing, to heighten the red color of madder. *See* CERUSS, LEAD, *and* VINEGAR.

## LIXIVIAL SALTS.

This is a general name given to all ſaline ſubſtances obtained by lixiviation of aſhes, but particularly applied to fixed alkalis, becauſe the ſalts thus obtained from aſhes are altogether or moſtly alkaline. *See* ALKALI (FIXED).

## NEUTRAL SALTS.

If this name be taken in its moſt extenſive ſenſe, it ought to be given to all the combinations of any acids with any alkaline, earthy, or metallic ſubſtances. Theſe are ſalts formed with baſis of fixed alkali, vegetable or marine; with baſis of volatile alkali, called ammoniacal ſalts; or with baſis of calcareous and argillaceous earths; and, laſtly, thoſe with baſes of metallic ſubſtances. *See the above enumeration of Salts.*

The name *neutral*, given to theſe ſalts, relates to the reciprocal ſaturation of their acids and their baſes. This ſaturation ought to be ſuch, that the properties of the two principles of the neutral ſalt ſhould be neither thoſe of a pure acid, nor of its pure baſis, but mixed or intermediate; and from hence theſe ſalts have alſo been called *intermediate ſalts*, or *ſales medii.*

The moſt important conſideration concerning theſe ſalts, is the juſt ſaturation of their two component principles. A neutral ſalt ought to be conſidered as perfect in its kind, when its acid and baſis are each of them in the moſt perfect relative ſaturation; that is, when the acid and the baſis are united together in as large quantity and as intimately as they can be, each according to its nature. But we muſt

remark upon this ſubject, that a neutral ſalt may be perfect in its kind, and exactly ſaturated in the ſenſe we have mentioned, although its principles be very far from being completely or abſolutely ſaturated, that is, although they have not exhauſted upon each other all their tendency to combine. In this reſpect the neutral ſalts differ much; and on this chiefly depend the eſſential differences evidently obſervable in the taſte, ſolubility, cryſtallization, deliqueſcence, facility of decompoſition, and action upon other ſubſtances, of theſe neutral ſalts.

From a circumſtantial examination only of the properties of neutral ſalts, we can acquire any knowledge concerning them; but we are far from having ſufficiently examined them: for beſides that many ſaline combinations are quite unknown, and have never been made, many things are yet undetermined even concerning thoſe ſalts which are beſt known. We need not therefore be ſurprized that we cannot yet eſtabliſh a good general theory concerning neutral ſalts. We ſhall here only mention ſome general principles which ſeem to reſult from what is already known, and which ſeem capable of leading us to further reſearches.

Firſt, the neutral ſalts, reſulting from the union of acids in general with fixed alkalis, are more abſolutely ſaturated than thoſe with baſis of volatile alkali, and theſe more than ſalts with baſis of earth, excepting ſelenites; and, laſtly, the ſalts with baſis of earth are more abſolutely ſaturated than ſalts with metallic baſes. In the firſt claſs of theſe ſalts, namely, thoſe with baſis of fixed alkali, we find moſt of the ſalts which have the leaſt taſte, ſolubility, deliqueſcence, action upon other bodies, or facility of decompoſition, and the greateſt tendency to cryſtallization. On the contrary, in the laſt claſs, namely, the ſalts with metallic baſes, we find moſt of thoſe that are corroſive, moſt ſoluble, deliqueſcent, leaſt cryſtallizable, moſt active upon other ſubſtances, and moſt eaſily to be decompoſed. The two intermediate claſſes with baſes of volatile alkali, and of earth, are alſo intermediate with regard to theſe properties.

Secondly, as the ſeveral acids are more or leſs ſimple and powerful, they form with the ſubſtances to which they are capable of uniting, neutral ſalts, the abſolute ſaturation of which is more or leſs perfect, according to the nature of the acid. Neutral vitriolic ſalts are the firſt in this reſpect, then nitrous and marine ſalts, or marine and nitrous ſalts; for theſe acids do not differ much; and, laſtly, acetous and tartareous ſalts.

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We ought to obſerve upon this ſubject of general conſiderations upon neutral ſalts, that we muſt not judge, from one or a few of their properties, concerning the degree of coheſion and of abſolute ſaturation of their principles, but from all their properties taken and compared together; becauſe poſſibly one of the principles of a ſalt may be abſolutely, or almoſt abſolutely, ſaturated, while the other principle may be far from this degree of ſaturation; and according as the acid or the baſe is moſt ſaturated, the properties of the neutral ſalt muſt vary conſiderably. For example; we ſhould be much miſtaken, if, upon conſidering that corroſive ſublimate is leſs ſoluble in water than common ſalt, and not at all deliqueſcent, as the latter ſalt is a little, we ſhould conclude, that the coheſion of the principles of corroſive ſublimate and their abſolute ſaturation are much ſtronger than in common ſalt. The corroſive quality of this ſalt, and its powerful action upon many bodies, which properties do not, or ſcarcely, exiſt in common ſalt, evidently prove the contrary. *See* SUBLIMATE (CORROSIVE).

We muſt alſo obſerve, that in many combinations of neutral ſalts, and particularly thoſe with metallic baſes, ſome metals and the acids themſelves ſuffer, by the very act of combination, certain alterations which have great influence on the nature of the neutral metallic ſalt reſulting from their union; for inſtance, although lunar and mercurial nitre be cryſtallizable, and little, if at all, deliqueſcent, while the nitres with baſes of copper and of iron are very much ſo, we muſt not thence conclude, that iron and copper ſaturate the nitrous acid leſs than ſilver and mercury do; becauſe we are certain that this difference does only proceed from this circumſtance, that while the nitrous acid diſſolves copper and iron, it decompoſes them, and deprives them of much of their inflammable principle which is neceſſary to the connexion of metals with acids, whereas it does not produce the ſame effect ſo evidently upon ſilver and mercury. Accordingly, the ſalts which reſult from the ſolution of copper and of iron by nitrous acid, ought not to be rigorouſly conſidered as combinations of theſe metals, but rather as combinations of their earth with this acid: for as nitrous acid quits ſilver and mercury to diſſolve copper and iron, probably if this ſolution could be made without loſs of the phlogiſton of theſe latter metals, they would more compleatly ſaturate this acid, and more firmly adhere to it, than the former metals.

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Many other considerations of this kind may be made concerning the different kinds of neutral salts; but the detail of them would engage us too long, besides that they will easily occur to those who would attentively reflect on this subject. We will however mention something concerning a discussion that has arisen lately betwixt some chemists relative to neutral salts.

Mr. Rouelle had advanced, in a Memoir of the Academy in 1754, that several of these salts may be in two different states; that is, they may be in a state of a perfect saturation, or, they may have an excess of acid. He cites for examples several combinations of metallic matters with acids, such as those of mercury with marine acid and with vitriolic acid, and that of bismuth with nitrous acid. Each of these metals may, according to him, form with the same acid two very different neutral salts, one of which has an excess of acid, and contains the largest possible quantity of acid; and the other is precisely saturated, and contains the smallest quantity possible of acid. This chemist cites also, as another instance of the same doctrine, the combination of a fixed alkali with an acid. It is that of the vegetable fixed alkali with vitriolic acid, forming consequently the neutral salt called *vitriolated tartar*. Mr. Beaumé has opposed this opinion in several Memoirs read at the Academy, and also in the Journal and Gazette of Medicine. He disputes the facts upon which Mr. Rouelle establishes his theory. He maintains, that many of the saline metallic combinations cited by Mr. Rouelle as examples, and considered by him as neutral salts containing the least possible quantity of acid, are nothing less than salts, but metals, deprived of all acid, when the acid which adheres superficially to the precipitated metal is sufficiently washed from it; and he thinks that Mr. Rouelle has been mistaken, from not having sufficiently washed these metallic precipitates which he considered as salts. Mr. Beaumé proves his opinion, by washing with a very large quantity of distilled and boiling water turbith mineral and mercurius vitæ; which precipitates he, by this method, deprived of every particle of acid.

With respect to the vitriolated tartar, the process by which Mr. Rouelle gives it an excess of acid is, by distilling in a retort two ounces of pure vitriolic acid upon this salt, till the salt is dry, and even till the retort has been kept red-hot during an hour. Mr. Rouelle observes, that when vitriolic acid is poured upon this salt, a considerable heat is excited, even when the salt has been deprived of the water of its

its cryſtallization by drying; and thence concludes, that the acid acts upon and combines with the ſalt. The ſaline maſs remaining after the diſtillation melts, and weighs, as Mr. Rouelle has obſerved, five ounces and one gros. This, according to him, is vitriolated tartar with exceſs of acid. He affirms alſo, that in this ſalt, as in all thoſe which are ſuſceptible of receiving exceſs of acid, there is a point of ſaturation of this exceſs of acid, and this point is marked in the preſent operation by the ceaſing of white vapors which riſe during the diſtillation. This vitriolated tartar with exceſs of acid has really an acid taſte; it attracts the moiſture of the air, reſolves into a liquor like the deliqueſcent ſalts, reddens the tinctures of violets and of turnſol, effervesces with fixed and volatile alkalis, and, laſtly, in cryſtallizing, remains acid.

Mr. Beaumé acknowledges almoſt all theſe facts; but he denies that we ought thence to conclude, that vitriolated tartar really contains an exceſs of combined acid. He ſupports his opinion upon the following facts and reaſons: Vitriolic acid diſtilled from pure ſand, in the ſame manner as Mr. Rouelle diſtilled that acid from vitriolated tartar, adheres to it in the ſame manner, although we are certain that it does not act upon ſand. In this therefore, and in many caſes, it is only an adheſion of juxta-poſition, which vitriolic acid is capable of contracting with any body from the degree of fixity which it has, eſpecially when perfectly concentrated.

In the ſecond place, the vitriolic acid, with which Mr. Beaumé affirms the vitriolic tartar is only ſuperficially covered, by Mr. Rouelle's proceſs, is ſo far from being truly combined, that it may be entirely ſeparated without fire, or any intermediate ſubſtances, by means purely mechanical: for by draining this ſalt very carefully upon brown paper, or even upon clean ſand, a vitriolated tartar perfectly neutral may be obtained, which preſerves the water of its cryſtallization, and conſequently the form and ſolidity of its cryſtals, and which no longer contains any veſtige of an acid. From theſe experiments Mr. Beaumé concludes, that this exceſs of acid in vitriolated tartar is not real, and is, like the unwaſhed metallic precipitates, miſtaken for ſalts with the leaſt poſſible quantity of acid, one of thoſe deceitful appearances againſt which we cannot too much guard. Mr. Beaumé generaliſes his propoſition concerning the exceſs of acid of vitriolated tartar, and affirms, that no neutral ſalt with baſis of fixed alkali either

has

has an excess of combined acid, or of combined alkali, although it be crystallized in an acid or an alkaline liquor; and that the acid or alkali, with which these salts are mixed, when crystallized in such liquors, is only interposed betwixt their parts, and may always be carefully separated from them solely by the mechanical method of imbibition.

The friends of M. Rouelle replied, that the means employed by M. Beaumé to separate the superabundant acid were not strictly *mechanical*; for that the moisture of the air contributed to decompose the acid vitriolated tartar, and to carry off its superabundant acid. M. Rouelle the younger maintains, that crystals of tartar afford another unquestionable instance of a salt crystallized with excess of acid. *See Memoirs Estrang. Tom.* VI.

We shall not enter more particularly into these subjects, which perhaps will hereafter be further illustrated. We shall only observe, that if we were to examine these matters as well as they deserve, it seems essential to distinguish first metallic salts from all others; for the greater or less degree of concentration of acids seems indifferent, with regard to the saline combinations which result from the union of these acids with earths and alkalis both fixed and volatile; that is to say, the same quantity of acid remains united with the earths or alkalis, whether the acid employed be concentrated or diluted with water: but metals, especially some certain metals, cannot be combined, or remain combined with acids, in the greatest possible quantity, unless the acid employed be in a proper degree of concentration; so that the same quantity of the same acid, which, when sufficiently concentrated, is capable of remaining united with a certain quantity of metal, can dissolve only a much less quantity of the same metal, if this quantity of acid be diluted with a larger quantity of water.

This singular phenomenon of metals relative to acids can be only attributed to the inflammable principle which enters into their composition. Metals in general adhere only to acids by this principle, and not by their earthy principle, or at least much more by the former than by the latter: but on the other side, the union of water with any body is an obstacle to the combination of that body with the inflammable principle. A quantity of acid, therefore, diluted with water, cannot be united but with a less quantity of metal than the same quantity of acid when concentrated. This seems to be naturally deduced from the fundamental principles of chemistry.

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In the ſecond place, we may remark, that after having diſtinguiſhed metallic ſalts from all others, we ought alſo to diſtinguiſh the combinations of mercury and marine acid, and even the corneous metals, from all other metallic ſalts. Theſe ſalts make a diſtinct claſs, and have a peculiar character. *See upon this ſubject the article* SUBLIMATE (CORROSIVE).

Notwithſtanding the diſtinctions we have ſhewn between the different kinds of neutral ſalts, we are far from believing that they can be methodically diſtributed, from conſidering any of their common properties, or claſſed, as plants have been by botaniſts; becauſe each of them has ſo many peculiar, and, at the ſame time, very eſſential properties, that the ſalts in the ſame claſs would often differ more from each other in their peculiar properties than they would be ſimilar in their common property by which the claſs is characteriſed. A proof of this truth may be ſeen in a Memoir inſerted in the Collection of the Academy for the year 1744, in which Mr. Rouelle has undertaken to claſs neutral ſalts according to their cryſtallization: for we find very different ſalts ranged not only in the ſame Section, but alſo under the ſame genus, as, for inſtance, *ſal ammoniac*, and the *combination of lead with marine acid.* We do not mean to depreciate Mr. Rouelle's attempt upon this ſubject, or thoſe of others in the ſame way, as we are convinced, that however unſucceſsful theſe may be in their particular object, they muſt encreaſe our knowledge by the many experiments and obſervations which they require, and by the compariſons and new views they occaſion. We need only to read the above Memoir of Mr. Rouelle to be convinced of this.

Neutral ſalts have many uſes in chemiſtry, arts, and medicine; but as theſe uſes depend upon the peculiar nature of each of them, we refer to the particular articles; and here we ſhall only ſay a little concerning their medicinal virtues.

We may obſerve, that theſe ſalts are antiſeptic when mixed in a proper doſe, that is, in a large doſe, with ſubſtances capable of putrefaction. Each of them reſiſts all kinds of fermentation more or leſs effectually: but the moſt exact experiments that have been made on this ſubject by Sir John Pringle, by the author of the Eſſay on Putrefaction, and by Mr. Gardane, phyſician at Paris, prove that theſe neutral ſalts, the principles of which are firmly connected, as all thoſe with baſis of fixed alkali, particularly common ſalt, rather accelerate than retard putrefaction. We find, from the experiments of the author of the Eſſay on

on Putrefaction, that the moſt powerful antiſeptics among the neutral ſalts are thoſe which are moſt aſtringent, as the neutral ſalts with metallic baſes.

All neutral ſalts with baſes of fixed alkali taken internally in the doſe of an ounce or more, produce in general a very mild purgative effect; and in ſmall doſes, as of one or two gros, they are only aperitive.

Ammoniacal ſalts are given in ſmall doſes only. They are exciting, dividing, and antiſcorbutic. The common ſal ammoniac is the only ammoniacal ſalt now uſed.

Moſt of the ſalts with baſes of calcareous earth are alſo conſidered as aperitive and dividing: but theſe ſalts differ much according to the nature of their acids. Thus ſelenitic ſalts are very different in their effects from nitrous and marine ſalts with calcareous baſes. Of thoſe ſalts, only the acetous, ſuch as the ſalts of coral, pearls, &c. are employed, and theſe but very little in France.

All the ſalts with the metallic baſes are corroſive, eſpecially thoſe containing mineral acids. Accordingly, they are not internally employed in medicine, excepting ſome of thoſe with baſes of mercury, iron, regulus of antimony. *See the articles* IRON, MERCURY, REGULUS *of* ANTIMONY, *and* TARTAR (EMETIC).

## NEUTRAL ARSENICAL SALT.

This ſalt is a combination of arſenic with fixed alkali to the point of ſaturation. Mr. Macquer firſt diſcovered this combination, and began an account of its properties in the Memoirs of the Academy for the years 1746 and 1748. His method of making this ſalt is, by mixing together equal parts of very white cryſtalline arſenic and purified nitre, and by diſtilling this mixture in a retort with a graduated heat in the uſual manner, till the retort is red-hot, and no more vapors of nitrous acid ariſe. In the retort a ſaline maſs remains, white, compact, and fixed; from which, after ſolution in hot water, filtration, evaporation, and cryſtallization, may be obtained beautiful, quadrangular, priſmatic cryſtals, terminated at each end by a quadrangular pyramid, the ſides of which correſpond with thoſe of the priſm.

Arſenic is known to have the property of decompoſing nitre, and of very eaſily diſengaging its acid; but, at the ſame time, it combines with the alkali of the ſalt, and ſaturates it preciſely as an acid would do; ſo that the new ſalt which reſults from this operation, when well made, is exactly

exactly neutral, and gives no marks of an alkaline quality. It is infinitely more soluble in water than pure arsenic, and dissolves in a less quantity of hot than of cold water.

This salt is easily fusible by fire, and remains fused and transparent like glass, without being alkalised, if it has not touched any inflammable matter: for it may be easily decomposed by phlogiston which unites with the arsenic, separates it from the alkali, and is sublimed. No pure mineral acid can decompose this salt, because arsenic seems to have a greater affinity with fixed alkali than acids have: but when these acids are united with metallic matters, they then easily decompose the neutral arsenical salt, even by the humid way; so that a solution of this salt added to a solution of metals occasions a precipitate composed of the arsenic and metal, while the acid of the metallic solution combines with the fixed alkali of the neutral arsenical salt, and forms another neutral salt. Thus two decompositions are made, and two new combinations are formed.

The uses of the neutral arsenical salt are not yet well determined; yet as the arsenic seems, from the properties mentioned, to be strictly united with the fixed alkali, this salt may probably be usefully employed, 1. for the preparation of the regulus of arsenic; 2. to combine arsenic conveniently with metallic matters; 3. in the composition of many glasses; 4. as the corrosive mineral acids form very mild salts when saturated with alkali, we may be induced to believe that arsenic completely saturated with a fixed alkali, as it is in neutral arsenical salt, might form a very mild salt, which may be powerful in medicine; but the name of arsenic is so terrible, that it will probably be never tried: but if it should, very numerous and long trials ought to be previously made on animals.

This salt might probably be useful in arts; for Mr. Beaumé prepares large quantities of it for different manufacturers; but the uses to which it is applied are kept secret. *See* ARSENIC.

## SALT *of* MILK.

Salt of milk is a neutral salt of a singular nature, and very little known. It is obtained from whey by evaporation and crystallization. As the evaporated whey from which it is obtained has a red color and a saccharine taste, that part of the salt of milk, which crystallizes first, has the same color and taste; and hence it has been called *sugar of milk*. If it be required more white and pure, it must be again

again diſſolved in pure water, and cryſtallized once or twice; and then it becomes very white, and has a farinaceous appearance even internally, although it is compact and hard. When thus purified, it is leſs ſaccharine, and has in general leſs taſte; becauſe it is diſengaged from the ſaccharine part of the milk, and even from a little common ſalt, which may afterwards be ſeparated from the whey.

Cryſtals of this ſalt ſeem to contain very little water: they have little taſte, and not deliqueſcent, nor very ſoluble, and ſeem to be difficultly decompoſed. They deſerve a farther examination.

Some perſons have imagined, that a liquor like whey might be made by diſſolving ſalt of milk in pure water; but this ſalt is only one of the conſtituent parts of whey; and conſequently the purer it is, the leſs can its ſolution imitate that liquor. *See* MILK.

## SAL POLYCHREST.

The word polychreſt is applicable to things which have many uſes: accordingly chemiſts ſay, that a furnace is polychreſt when it is ſo conſtructed that different operations may be made with it.

For the ſame reaſon, the inventors of ſome ſalts have given them this epithet to denote their various powers in medicine. Hence we have the *ſal polychreſt of Glaſer*, which is a vitriolated tartar, made by the detonation of nitre with ſulphur; the *ſal polychreſt of Rochelle* or *of Saignette*, which is a tartareous ſalt, or a ſoluble tartar with baſis of marine alkali. *See* SALT *of* SAIGNETTE, *and* TARTAR (VITRIOLATED).

## POTASH.

Potaſh is a purified, fixed, vegetable alkali, obtained from the aſhes of wood. *See* ALKALI (FIXED VEGETABLE).

## SALT *of* SAIGNETTE *or of* ROCHELLE.

This ſalt is a ſoluble tartar with baſis of marine alkali, or a neutral ſalt formed by ſaturating the acid of tartar with marine alkali.

This ſalt was firſt compoſed for medicinal purpoſes, in imitation of ordinary ſoluble tartar or vegetable ſalt, by Mr. Saignette, apothecary at Rochelle, who brought it into

into vogue, and kept it ſecret as long as he could. Meſſ. Boulduc and Geoffroy afterwards diſcovered, and publiſhed its compoſition.

To prepare this ſalt, cryſtals of marine alkali are to be diſſolved in hot water, and into this liquor powdered cream of tartar is to be thrown: when the effervescence ceaſes, more cream of tartar is to be added, till the liquor is ſaturated: it is then to be filtered and evaporated; and very fine and large cryſtals may be obtained by cold, each of which is the half of a polygonous priſm cut in the direction of its axis. This ſection, which forms a face much larger than the reſt, is, like them, a regular rectangle, diſtinguiſhable however from the others, not only by its breadth, but alſo by two diſtinct diagonal lines which interſect each other in the middle.

Mr. Beaumé has obſerved, that the cryſtallization of this ſalt, and alſo of the vegetable ſalt, is much more eaſy and beautiful when the liquor in which it is made contains an exceſs of alkali, which does not prevent the ſalt from being exactly neutral, after it has been well drained.

Salt of Saignette has a ſaline taſte, moderately ſtrong, and diſagreeable. It retains much water in its cryſtallization, is ſoluble in a leſs quantity of hot water than of cold water, and conſequently cryſtallizes well by cold. It becomes farinaceous in a dry air, both from the quantity of water of its cryſtallization, and from the marine alkali which enters its compoſition. In other reſpects, it has all the general properties of *neutral tartareous ſalts*, or *ſoluble tartars*.

Salt of Saignette is uſed only in medicine. It is a good purgative, taken from an ounce to an ounce and a half. It is much uſed as ſuch, and is, for that purpoſe, diſſolved in pure water, or in ptiſans and mineral waters, to render them purgative. It is alſo given in ſmall doſes of one or two gros, as an alterative, aperitive, and corrector of other purgative ſubſtances. Although this ſalt really poſſeſſes theſe good qualities, it does not ſeem to differ much from ordinary ſoluble tartar, to which it is generally preferred. *See* TARTAR, ALKALI (MINERAL), *and* TARTAR (SOLUBLE).

## SALES SALSI.

This is one of the names given to neutral ſalts, particularly to thoſe which have a taſte ſomething reſembling that of common ſalt. *See* SALT (NEUTRAL).

## SEDATIVE SALT.

This ſalt is a ſaline, concrete, and cryſtallized ſubſtance, obtained from borax by means of acids. This matter, although it acts as an acid in borax, and perfectly ſaturates its alkali, has not an acid taſte, nor the property of reddening the tinctures of violets and turnſol, as the acids properly ſo called do. Sedative ſalt has little taſte and ſolubility in water. It is a kind of neutral ſalt, which has only ſome properties common to it with acids, as we ſhall afterwards ſee.

Sedative ſalt may be obtained from borax by ſublimation, or by cryſtallization. The moſt common proceſs for obtaining this ſalt by ſublimation is that of Homberg, the diſcoverer of ſedative ſalt. This proceſs conſiſts in mixing martial vitriol with borax, in diſſolving them in water, in filtrating and evaporating the liquor till a pellicle appears: the liquor is then to be put in a ſmall glaſs alembic, and the ſublimation is to be promoted till only a dry matter remains in the cucurbit.

During this operation, the liquor paſſes into the receiver; but the internal ſurface of the capital is covered with a ſaline matter forming very ſmall, thin, laminated cryſtals, very ſhining and very light. This is the ſedative ſalt. The capital is then to be unluted, and the adhering ſalt ſwept off with a feather: the part of the liquor which paſſed laſt into the receiver is to be poured on the dry reſiduum of the cucurbit, and a new ſublimation is to be promoted as before, by diſtilling till the matter in the cucurbit be dry: theſe operations are to be frequently repeated in the ſame manner, till no more ſedative ſalt can be ſublimed.

Sedative ſalt may be obtained by cryſtillization. For this purpoſe, let borax be diſſolved in hot water; and to this ſolution, when filtrated, add any one of the three mineral acids, a little at a time, till the liquor be ſaturated, and even have an exceſs of acid, according to Mr. Beaumé's proceſs: the liquor is then to be left in a cold place, and a great number of ſmall, ſhining, laminated cryſtals will be formed: Theſe muſt be waſhed with a little very cold water, and drained upon brown paper. This is the ſedative ſalt obtained by cryſtallization. It is very beautiful and ſhining, but is ſomewhat denſer than the ſalt obtained by ſublimation. This latter is ſo light, that one gros is ſufficient to fill a large phial.

The

The acids, either of the martial vitriol, or the diſengaged acids in the latter proceſs, do only diſengage this ſalt from the marine alkali with which it formed borax, as Mr. Baron has diſcovered. Accordingly, this ſalt, when well prepared, does not partake in any manner of the nature of the acid by means of which it has been diſengaged. Sedative ſalt obtained by cryſtallization does not differ eſſentially from that which is ſublimed, only that the cryſtals or laminæ of the latter are more ſeparated and detached than thoſe of the former.

Sedative ſalt, although it be thus ſublimed, is not however volatile; for, as Mr. Rouelle obſerves, it only riſes by means of the water of its cryſtallization. We know that when once it has loſt its water by drying, it cannot be raiſed into vapors by the moſt violent fire, in which it remains fixed, and melts into a vitreous matter, as borax does.

This vitrified ſedative ſalt preſerves its ſaline character; and, although it has a beautiful cryſtalline appearance, it is only ſedative ſalt deprived of all moiſture and melted. It is entirely ſoluble in water, and may then be cryſtallized or ſublimed, as at firſt, into its proper form.

A great quantity of water is required to diſſolve ſedative ſalt, and much more of cold than of boiling water. It may therefore be cryſtallized by cold, and is alſo cryſtallizable by evaporation alone.

Mr. Beaumé has made an intereſting obſervation upon this method of diſengaging and cryſtallizing ſedative ſalt, which is, that we muſt add a little more acid to the ſolution than is ſufficient for the ſaturation. He remarks, that when only the preciſe quantity of acid is added to decompoſe all the borax, the ſedative ſalt remains confounded with the other ſaline matters contained in the liquor, and the cryſtallization is conſequently diſturbed. This inconvenience is avoided by the addition of a little more acid than is ſufficient for the ſaturation of the alkaline baſis of the borax. The ſedative ſalt, although formed in a liquor thus acidulated, may be entirely deprived of an exceſs of acid, which is not combined with it, by means of draining upon paper, according to the principles of Mr. Beaume.

The acid that is mixed in the hot ſolution of borax decompoſes this ſalt, becomes ſaturated with its alkaline baſis, and inſtantly diſengages the ſedative ſalt; all which is effected without any effervescence. The ſedative ſalt does not cryſtallize as ſoon as it is diſengaged, although the

liquor be at the point of cryſtallization, when only the preciſe quantity of water is added which is neceſſary for the ſolution of the borax. The heat is the cauſe of this; for as ſoon as the liquor cools, a conſiderable quantity of cryſtals is perceived.

From the above-mentioned properties of the ſedative ſalt, by which it reſiſts fire, ſo as to be capable of vitrification, without being otherwiſe altered, we may perceive that it is a ſaline compound, the principles of which are ſtrictly united, and very difficultly ſeparable. This truth has been illuſtrated by numerous and accurate experiments on this ſubject by Mr. Bourdelin, related in the Memoirs of the Academy for the years 1753 and 1755.

From theſe experiments we find, that ſedative ſalt reſiſts the moſt powerful agents for the decompoſition of ſaline ſubſtances. It was unaltered by treatment with inflammable matters, with ſulphur, with mineral acids diſengaged, or united with metallic ſubſtances, and with ſpirit of wine. Mr. Bourdelin could only perceive ſome marks of an inflammable matter, and a little marine acid, in this ſalt. The former he diſcovered by a ſmell of ſulphureous acid communicated by it to vitriolic acid; and the latter by a white precipitate formed in a ſolution of mercury, by the liquor obtained from the diſtillation of a mixture of this ſalt with powder of charcoal. Mr. Bourdelin does not poſitively affirm the laſt propoſition; but acknowledges, with all chemiſts, that we do not know the nature of ſedative ſalt, from not having been able to decompoſe it.

As this ſalt has the property of diſengaging the acids of nitre and of common ſalt by uniting with their baſes, and alſo as it is very vitrifiable, and promotes the vitrification of other ſubſtances, moſt chemiſts believe that it is compoſed of vitriolic acid intimately combined with a fuſible and vitreſcible earth.

This is one of the ſalts which are ſoluble in ſpirit of wine, to the flame of which it communicates a green color. As only the ſaline combinations of copper are known to be capable of giving this color to the flame of ſpirit of wine, ſome chemiſts have been induced to believe, that ſedative ſalt might contain copper, or the calx of copper.

Laſtly, we may ſuſpect ſome analogy betwixt the ſedative ſalt, on one ſide, and arſenic and phoſphoric acid on the other, from ſome properties which each of theſe ſubſtances have, and particularly from their action upon certain ſalts, and from their vitreſcible quality. But theſe latter ſub-

ſtances

ſtances are not better known than ſedative ſalt; therefore all that we can ſay upon this ſubject is, that much yet remians to be diſcovered concerning all theſe matters.

Excepting the uſes of borax in vitrifications, and in fuſions and ſoldering of metals, ſedative ſalt is only employed in medicine. Homberg, its inventor, believed that he diſcovered in it a ſedative, antiſpaſmodic, and even narcotic quality, and thence called it the *narcotic ſalt of vitriol.* It was generally employed in convulſive diſeaſes after the praiſes Homberg had beſtowed upon it; but its ſedative powers have not been well aſcertained. The beſt practitioners even affirm, that, to produce any effect, it muſt be given from half a gros to a gros, inſtead of doſes of a few grains, which were given at firſt. *See* BORAX. *(u)*

## SALT *of* SODA.

This is one of the names given to marine or mineral alkali obtained from the aſhes of ſoda and of other maritime plants. *See* ALKALI (MINERAL).

## SULPHUREOUS SALT *of* STAHL.

This name is given to a neutral ſalt, compoſed of volatile ſulphureous acid, combined to the point of ſaturation with fixed vegetable alkali.

*(u)* SEDATIVE SALT. Mr. Cadet has publiſhed, in the Memoirs of the Royal Academy of Sciences for the year 1766, an account of ſome experiments made by him upon borax and the ſedative ſalt. From theſe he infers, 1. That the acid contained in borax is the marine, he having made a corroſive ſublimate with this acid and the mercurius precipitatus per ſe. 2. That the ſedative ſalt does not exiſt in borax, but is produced during the proceſs. 3. That this ſedative ſalt is compoſed of the marine acid originally exiſting in the borax, of the vitriolic acid employed in the operation, and of a vitreſcible earth. 4. That this vitreſcible earth is the ſame as that which is generally ſeparated from borax during its ſolution in water, and which abounds more in the unrefined than in the refined borax. 5. That this earth conſiſts of a calx of copper, from which, by reduction, he obtained a regulus of copper. 6. That borax therefore is compoſed of a calx of copper united with marine acid, and with mineral alkali. The ſame chemiſt purpoſes to make further experiments on this ſingular ſalt. But M. Beaumé maintains that the copper is only accidental in borax, and proceeds from the veſſels uſed in the preparation of this ſalt; but that no copper can be obtained from pure borax.

This ſalt may be made either by ſaturating fixed alkali with volatile ſulphureous acid made in a cracked retort, in Stahl's manner, or by expoſing linen ſoaked in liquid fixed alkali to the vapors of ſulphur ſlowly burning. When this latter method is employed, the linen dries, becomes ſtiff, and ſhines with many ſmall needle-like cryſtals, which are the ſulphureous ſalt.

Volatile ſulphureous acid does not differ from pure vitriolic acid but by a portion of phlogiſton, which is only weakly united with it, but is however ſufficient to diſguiſe conſiderably the eſſential properties of this acid. Sulphureous vitriolic acid has not only a pungent ſmell and volatility which the pure vitriolic has not, but it alſo forms with different ſubſtances, particularly with fixed alkali, neutral ſalts very different from thoſe formed by the union of theſe ſubſtances with pure vitriolic acid. Stahl firſt obſerved this ſalt, which is the only one known of all the combinations of the ſulphureous acid.

This ſulphureous ſalt has a more pungent taſte than vitriolated tartar, is more ſoluble in water, and is cryſtallizable by cold. Its cryſtals are like needles attached to each other by their ends, forming tufted cluſters of cryſtals; in which reſpect alſo it differs from vitriolated tartar, and is ſomewhat analogous to nitre.

This ſalt may be decompoſed by any acid, and its ſulphureous acid expelled from it. Thus vitriolic acid, from being naturally the ſtrongeſt of any, is rendered the weakeſt of all, merely by union with the inflammable principle, which is only weakly combined with it.

The natural volatility of the phlogiſtic principle, and its weak adheſion to the volatile ſulphureous acid, occaſion a gradual change of the nature of the ſulphureous ſalt. This ſalt is perpetually changing, from the conſtant diſſipation of its phlogiſton. It gradually loſes its peculiar properties by which it differs from vitriolated tartar, becomes more and more ſimilar to this ſalt, and at laſt, when it has loſt all to its phlogiſton, does not in many reſpects differ from it. Probably we might obſerve the ſame changes in the combinations of ſulphureous acid with other ſubſtances; nevertheleſs thoſe which, like metals, have a ſtronger affinity with phlogiſton than alkali has, may perhaps produce effects very different.

All the phenomena of the ſulphureous ſalt, of the volatile ſulphureous acid, and of ſulphur, with regard to their ſeveral combinations, are naturally deducible from this general

general principle, that the affinities of the most compound bodies are always weaker than those of the most simple substances. *See* VOLATILE SULPHUREOUS ACID, *and* ACID (VITRIOLIC).

## FEBRIFUGAL SALT *of* SYLVIUS.

This is a neutral salt composed of marine acid saturated with fixed vegetable alkali. It is also called *regenerated sea salt*, but improperly, because the basis is different from that of sea salt, excepting its taste, which is not so agreeable as that of sea salt. It resembles this salt in its crystallization, and in most of its essential properties. It does not seem to deserve the epithet *febrifugal*, although it may, when given in proper doses, as a purgative and antiseptic, contribute to the cure of some fevers, which qualities are common to it with other neutral salts. It is not now employed. *See* ACID (MARINE), ALKALI (FIXED), *and* NEUTRAL SALTS.

## SALTS *of* TAKENIUS.

The salts prepared in Takenius's manner are impure fixed alkalis, obtained from the ashes of vegetables burnt for that purpose in a peculiar manner, namely, by suffocating their flame, and leaving no more communication with the air than is sufficient for the burning of their most disengaged inflammable parts.

When therefore we would prepare the fixed salts of a plant according to this method, the dried plant is put in an iron pot, which is to be heated so that its bottom shall be red. The plant must be continually stirred; a thick fume will exhale from it, and at length a flame rises. The pot is then to be covered with a lid, which must be so loose that the flame only will be extinguished, and the smoke will pass out. The lid must be taken off sometimes, that the plant may be stirred. When the plant is by this method reduced to a kind of ashes, these ashes must be lixiviated with boiling water; and when the lixivium has been evaporated to dryness, a saline matter more or less reddish will remain, which ought to be kept in a bottle. This is the fixed salt of the plant prepared in Takenius's method.

By burning plants in this manner, the fixed alkali obtained is evidently phlogisticated, rendered semi-saponaceous, similar to that which is prepared for the making of

Pruſſian blue, and mixed with all the neutral ſalts contained in the plant. Theſe impure alkalis have been intended only for medicinal uſes. Some perſons have imagined that they could retain much of the virtue of the plant from which they have been obtained. But although we do not doubt that the fixed ſalts of different plants, prepared in this method, differ conſiderably from each other; yet as the medicinal virtues of vegetables depend chiefly on their proximate principles, and as theſe principles are totally changed, and decompoſed by burning, even when they are made with the precautions which Takenius mentions, theſe ſalts retain none of the virtues of the plants from which they are produced when alkalis are required. They are only ſemi-ſaponaceous fixed alkalis, much leſs cauſtic than well purified alkalis, and therefore may be preferred in medicine. Theſe alkalis partake beſides of the virtues of the neutral ſalts with which they are mixed.

## SALT *of* TARTAR.

This name is commonly given to the fixed alkali of tartar, and even frequently to fixed vegetable alkali in general. *See* ALKALI (FIXED).

## VEGETABLE SALT.

This ſalt, called alſo *ſoluble tartar*, and *tartariſed tartar*, is a combination to the point of ſaturation of cream of tartar, or acid of tartar with fixed vegetable alkali. It is prepared and cryſtallized like ſalt of Saignette, from which it differs in its alkaline baſis. The cryſtals of this ſalt are much ſmaller than thoſe of ſalt of Saignette. In other reſpects it has the ſame properties, chemical and medicinal. *See* SALT *of* SAIGNETTE, TARTAR, *and* TARTAR (SOLUBLE).

## SALT *of* VINEGAR.

The ſalt ſold by apothecaries under this name is nothing but vitriolated tartar, impregnated with very ſtrong radical vinegar.

As pure radical vinegar cannot be obtained in a concrete ſtate but with very great difficulty, and as it does not retain this concrete ſtate when it has once received it, as the Count de Lauraguais has ſhewn, when a ſalt of vinegar is required with a very pungent and penetrating ſmell, to be kept

kept in bottles, like the concrete volatile alkali called ſalt of England, a better expedient has not been found than that we have mentioned. This mixture has a ſmell of radical vinegar, almoſt as pungent as that of volatile alkali, although the kind be very different; and is applicable to the ſame purpoſes, namely, to relieve hyſterical paroxyſms. *See* VINEGAR.

## VOLATILE SALTS.

This name is frequently given to volatile, concrete alkaline ſalts. Thus *volatile ſal ammoniac*, and *volatile ſalt of hartshorn*, are the volatile alkalis obtained from theſe ſubſtances. Nevertheleſs, the ſame name is ſometimes given to other ſaline ſubſtances of very different natures, for inſtance, *the ſalt of amber*, which is acid, and is called *volatile ſalt of amber*, which is certainly an inconvenience. The appellation *volatile ſalt* may be given to all ſaline matters really volatile, that is, which may be ſublimed with a moderate heat. But as theſe ſalts are of very different kinds, they ought to be diſtinguiſhed by ſome more particular name. The volatility of ſalts is a very indeterminate quality. For of thoſe which are conſidered as ſuch, ſome are much more, and ſome much leſs volatile than others.

Theſe ſalts are called *ſemi-volatile* which cannot be ſublimed without a fire ſufficient to render the bottom of the veſſel containing them red-hot, ſuch as moſt ammoniacal ſalts, ſweet mercury, and ſome others. And thoſe are called *fixed ſalts*, which may be kept red-hot during a certain time without ſenſible loſs. But, rigorouſly ſpeaking, no ſalts are abſolutely fixed; for, as we have ſaid elſewhere, the alkalis called fixed, and the other ſalts which are conſidered alſo as fixed, are diſſipated in fume when long expoſed to a violent fire, with acceſs of air. *See* ALKALIS (VOLATILE), FIXITY, VOLATILITY.

## URINOUS SALTS.

This name was given by ancient chemiſts to all alkaline ſalts, volatile or fixed; to the former, becauſe they all have the taſte of putrefied or diſtilled urine; and to the fixed, becauſe although they have not themſelves this taſte, they however occaſion it, when applied to the tongue, by diſengaging the volatile alkali contained in animal ſubſtances. Therefore *urinous ſalts* and *alkaline ſalts* are ſynonimous. *See* ALKALI.

## SALT *of* STEEL.

Some chemists have given this name to several combinations of iron with acids, even to martial vitriol, as appears from *Riverius's salt of steel*, which is a martial vitriol made with iron, vitriolic acid, and spirit of wine. *See* VITRIOL.

SALT-PETRE. *See* NITRE.

SAND. Sand is composed of small stony matters. The kinds of sand may therefore be as many as the kinds of stones. Most sands consist of different kinds of stones mixed together. But as soft stones are easily reducible into so small particles, that they are more like powders or earths than sand; and as the molecules of hard or vitrifiable stones are capable of preserving longer their size; hence most matters called sand are of the nature of vitrifiable earths. *See* EARTHS (VITRIFIABLE). Accordingly, by the name of sand, we understand always, in natural history and in chemistry, a matter of the nature of vitrifiable earths.

The principal use of sand in chemistry is in compositions for pottery and glass. Some sands are more and some less fusible. The particles also of some are larger than those of others. The finer kind is generally used for vitrifications, and other chemical operations, because it is naturally much divided: It is frequently employed to make a *sand-bath* to transmit heat to vessels placed in it.

SANDARACH. This is a yellow or red combination of arsenic with sulphur. *See* ARSENIC, *and* REALGAR.

SANDIVER. *See* GLASS-GALL.

SAPHIRE. *(x)*

SARCOCOLLA. *(y)*

SARSAPARILLA. *(z)*

*(x)* SAPHIRE is the name of a pellucid blue gem, the hardness of which is next to that of the ruby. By fire it is unfusible, but its color is thereby destructible. It may be imitated by fusing a hundred parts of crystal glass-fritt with one part of zaffre, and a very small proportion of manganese.

*(y)* SARCOCOLLA is a gum-resin, of an ounce of which six drams were found to be soluble by spirit of wine; and seven drams and a half were found to be soluble by water. *Neuman.*

*(z)* SARSAPARILLA. From sixteen drams of this root Neuman obtained by water six drams of gummy extract, and from an equal quantity he obtained by spirit four drams of resinous extract.

SAS-

SASSAFRAS. *(a)*

SATURATION. All the particles of matter have, as is ſaid under the articles AFFINITY, COMBINATION, SOLUTION, *and* GRAVITY, a tendency to unite one with another. In fact, when they are united, and when this tendency is ſatisfied, it is called the ſtate of *ſaturation*, and then the whole effect of this tendency, or of this force, conſiſts in making them cohere together. But all the phenomena of chemiſtry ſhow, that the tendency to union of the parts of different ſubſtances is more or leſs ſtrong, according to the nature of theſe ſubſtances. Hence the parts of two ſubſtances may be united together with all the force of which they are ſuſceptible, reſpectively to each other, although their tendency to union in general be very far from being entirely exhauſted and ſatisfied.

This remark leads us to conſider ſaturation in two views, that is, that we ſhould diſtinguiſh the ſaturation of one ſubſtance relatively to another, from the greater or leſs diminution of tendency to union in general, which a ſubſtance has ſuſtained by means of any particular union contracted. This latter we ſhall call *abſolute ſaturation*, and the former *relative ſaturation*.

Theſe things being premiſed, as the general tendency to union diminiſhes always in proportion to the force with which the parts are united, hence the adheſion more or leſs ſtrong, contracted betwixt the principles of any compound, influences much the nature and eſſential properties of this compound; for example, when the principles of a body are capable of uniting together with all their general tendency to union, their relative ſaturation is then confounded with their abſolute ſaturation, ſo that after their union, no tendency to new unions can be perceived in theſe bodies, or in any of their principles. Such are the neutral ſalts compoſed of mineral acids and fixed alkali. So ſtrong an union is contracted by the acid and alkaline principles of theſe ſalts, that they loſe entirely, or almoſt entirely, their taſte, cauſticity, activity; in a word, all the properties

*(a)* SASSAFRAS. The wood of this tree contains the heavieſt of all known eſſential oils. Of this oil Hoffman obtained an ounce and ſix drams from ſix pounds of the wood; and Neuman obtained from an equal quantity of wood, two ounces. From an ounce of ſaſſafras four ſcruples of extract were obtained by means of rectified ſpirit; and from an equal quantity of the wood two drams were extracted by water. *Neuman.*

which

which before this union were occasioned by their general tendency to combination. Accordingly, the relative saturation of these is very distinct, and is one of the first which has been observed.

When, on the contrary, the principles of a compound can contract together only a weak union, and consequently do not exhaust by this union all their general tendency to combination, not only their point of relative saturation is less distinct, but also these principles, although relatively saturated by each other, are far from absolute saturation, and still preserve, notwithstanding this union, much of their dissolving power. Compounds of this kind are always considerably active, and even caustic according to the nature of their principles. Such are deliquescent salts, and particularly most salts composed of mineral acids and metallic substances, the causticity of which cannot be otherwise explained. *See the articles* CAUSTICITY, *and* SUBLIMATE (CORROSIVE).

Many substances have a determinate and considerably distinct point of relative saturation, although they contract together but a weak union. But if we attend, we shall perceive that all these substances possess but a small quantity of dissolving power, or a weak general tendency to combination. Their relative saturation is nearly equal to their absolute saturation. Such are ether with water, essential oils with spirit of wine, and most neutral salts with water. If we mix together and agitate good ether with water, a part of the ether unites with the water, nearly in the proportion of one to ten; so that if one part of ether be added to ten parts of water, all the ether disappears by being diffused through the water, as the Count de Lauraguais observes. If the quantity of ether be more than one tenth part of the water, the overplus will float distinct upon the surface of the water, like an oil.

Also well rectified spirit of wine can only dissolve a determinate quantity of each kind of essential oil, which quantity varies according to the kind of oil, and to the state in which it happens to be. In general, the more attenuated they have been by rectification, the more they are removed from a resinous state, and the smaller quantity of them is soluble. And also the more highly rectified a spirit of wine is, the larger quantity of oil it dissolves.

Water is the proper solvent of neutral salts. It is capable of dissolving any of them, but most of them only in a certain quantity: and this point of saturation of water differs with

with different ſalts, and degrees of heat applied. The point of ſaturation is moſt diſtinct with thoſe ſalts which contain a ſmall quantity only of the water of cryſtallization, and which are nearly equally ſoluble in hot and in cold water. Such are vitriolated tartar, and, ſtill more, common ſalt.

When the water is once ſaturated with theſe kinds of ſalts, the ſtrongeſt and longeſt boiling does not diſſolve a grain more, and the overplus of the ſalt remains entire at the bottom of the boiling water: But boiling water diſſolves an equal, or even an unlimited quantity of ſome ſalts, chiefly of thoſe which contain much water in their cryſtallization, ſuch as Glauber's ſalt, alum, borax, martial and cupreous vitriols, and others of that kind. The water of cryſtallization of theſe ſalts is alone ſufficient to keep them diſſolved, by means of heat. Hence, when they are expoſed to fire without water, they ſuffer a liquefaction, which is very different from fuſion, and is nothing elſe than a ſolution of the ſalt in the water of its cryſtallization, and conſequently laſts only till this water be evaporated. The point of ſaturation of water for theſe ſalts ſeems to be indeterminate.

Many ſubſtances are capable of uniting without being preciſely ſaturated, ſuch as water with any of the following ſubſtances; fluor acids, fixed vegetable alkali, fluor volatile alkali, moſt of the very deliqueſcent neutral ſalts, and ſpirit of wine. Such alſo are almoſt all metals uniting with each other: Although many of theſe ſubſtances have a great affinity together, as the fluor acids and alkalis with water, yet all their general tendency to combination is not exhauſted in theſe kinds of union. On the contrary, their union is little elſe than a very accurate and intimate mixture. Their diſſolving power is not ſatisfied by ſuch an union, but is almoſt entirely preſerved. We need not therefore be ſurpriſed, that no preciſe or determinate point of ſaturation is obſerved betwixt theſe ſubſtances. We may ſay, in general, that the point of relative ſaturation is ſo much more exact, diſtinct, and determinate, as the bodies which unite together have a ſtronger affinity, as they more compleatly exhauſt upon each other their diſſolving power, or as their relative ſaturation is more nearly equal to their abſolute ſaturation.

The examination of the ſeveral degrees of ſaturation which ſubſtances may ſuſtain by combining together, is an object as important as it is new in chemiſtry. This matter has

has been ſcarcely begun, and yet it well deſerves the attention of chemiſts, as it would greatly advance the ſcience. We could not treat this ſubject more fully without repeating what has been ſaid elſewhere. We therefore refer to the articles *affinity*, *combination*, *compoſition*, *ſolution*, *cauſticity*, *gravity*, *ſalts*, *neutral ſalts*, *corroſive ſublimate*; and ſeveral others.

SAUNDERS. *(b)*
SCAMMONY. *(c)*
SCORDIUM. *(d)*
SEA-WATER. *See* WATER.

*(b)* SAUNDERS. The wood of the tree, called *red ſaunders*, contains a red coloring material uſed in dying. Its color reſides wholly in a reſinous matter, and hence is extractable by ſpirit of wine, and not by water. The red color of Saunders, imparted to ſpirit of wine, becomes, by diluting the tincture with more ſpirit, yellow. The reſin gave a deep red color to oil of lavender, and a pale red to oil of almonds and to oil of aniſeeds, but no color to oil of amber and to oil of turpentine. The wood of the tree, called *yellow ſaunders*, is from its fragrance ſometimes employed as a perfume. From ſixteen ounces of the raſped wood, digeſted ſome days in ſalt water, two drams of eſſential oil were obtained by cohobation. Two drams of gummy extract may be obtained from two ounces of the wood by water; and from an equal quantity of wood, two drams and a half of reſinous extract may be obtained by rectified ſpirit. *Neuman.*

*(c)* SCAMMONY is a gummy-reſinous juice, which exſudes from the root of a ſpecies of convolvulus, in which inciſions are purpoſely made at a certain ſeaſon of the year. An ounce of Smyrna ſcammony yielded with water half an ounce of gummy extract, and the reſiduum yielded with ſpirit two drams of reſin, leaving two drams of impurities undiſſolved. By applying rectified ſpirit at firſt to an ounce of the ſame ſcammony, two drams and two ſcruples of reſinous extract were obtained; and from the reſiduum, water extracted half an ounce of gum, the indiſſoluble part amounting here to four ſcruples only. *Neuman.*

*(d)* SCORDIUM. An ounce of the dried leaves of ſcordium yielded with water four drams and a half of gummy extract, and afterwards with rectified ſpirit fifteen grains of reſin. Another ounce, treated firſt with ſpirit, gave three drams of reſinous extract, and afterwards with water, five ſcruples and a half of gum. A tincture, made in highly rectified ſpirit of wine, contains more of the active and leſs of the mucilaginous parts of this plant, than one made with a weaker ſpirit.

SELENITES.

SELENITES. Modern chemists give this name to a sort of neutral salt formed by the union of vitriolic acid with any calcareous earth. Vitriolic acid and calcareous earth are capable of combining together to the point of saturation in the most intimate manner. Probably a very considerable quantity of earth enters into this combination, at least if we judge of it by the saturation of vitriolic acid, which appears to be more compleat than in any of the other neutral salts formed with this acid. This truth is sufficiently established by the properties of selenites.

Nature furnishes us with a very large quantity of selenitic matters. Chemists agree that all gypsums or plaster-stones, alabasters, and gypseous spars, are nothing else than selenites; but these substances are in large quantities within and upon the earth. We may also artificially compose selenites, by combining vitriolic acid to the point of saturation with calcareous earth. To effect this saturation easily, the calcareous earth must be in fine powder, the acid must be diluted in a very large quantity of water, and more earth must be added than is necessary for the saturation. Selenites may also be conveniently made by saturating lime-water gradually with weak vitriolic acid; or, lastly, by pouring this acid into a solution of nitrous or marine salts with calcareous bases. In these latter operations the selenitic salt renders the liquor turbid, and is precipitated.

Selenites, natural or artificial, when well washed from all excess of acid or other extraneous matter, has a slightly nauseous taste, which is scarcely perceptible but by drinking a glass of water impregnated with it, like that of the wells in and near Paris, the sweetish and slightly nauseous taste of which is well known.

This earthy salt is one of the least soluble by water of all the known neutral salts. Seven or eight hundred parts of water are required to dissolve one part of selenites, excepting when its principles are combined, and the salt formed in the water, as Mr. Beaumé has observed; for then the water may dissolve four or five times as much. By a slow evaporation it crystallizes, and forms thin laminæ, and retains in its crystallization a very small quantity of water.

When it is exposed to a moderate fire, it easily loses this water of its crystallization, with its transparency and cohesion of its parts, and is reduced to a white powder.

With

With a very great fire, it is not fusible when alone, *(e)* but is more easily fusible than pure calcareous earth, by the addition of fluxes, as sand, and clay, and vitrifying salts. It resists the greatest heat without losing its acid. It cannot be decomposed by phlogiston, by alkalis fixed or volatile; and by metallic solutions in nitrous acid, by means of a double affinity. Thus the solution of mercury readily shews whether a water be selenitic or not, by forming a precipitate of turbith-mineral when added to such waters. As selenitic matters are copiously diffused, and almost every where within the earth, most waters of wells, or rivers, contain a greater or less quantity of selenites dissolved in them, as we may easily find by the abovementioned method of trial.

Nothing better shews the extreme difference betwixt vitriolic and other mineral acids, than the comparison of the saline properties of selenites with those of nitrous and marine salts with calcareous bases. The earthy basis is the same in these three salts; but the two latter have a violent, almost caustic taste, and are surprisingly deliquescent; while the first salt is very difficultly soluble in water, and almost insipid. The cause of these differences is, that vitriolic acid is more simple than the other acids, and is therefore capable of being more intimately combined and saturated with calcareous earth.

This kind of salt has been called selenites, probably because naturalists found its saline properties so weak, that they thought it ought to be distinguished from other neutral salts by a peculiar name. Perhaps they did not even believe it to be saline; for the nature of selenitic matters has been discovered but lately by experiments of modern chemists.

We are not enough acquainted with calcareous earths to know if selenites be of different kinds, or if all the substances to which this name is given are only one and the same salt under different forms of crystallization. If the kinds of calcareous earth be essentially different, they must form with vitriolic acid several kinds of selenites also essentially different from each other. But if only one kind of calcareous earth exists, then it can only form one kind of selenites.

*(e)* From Mr, D'Arcet's Memoir upon the effects of a violent and long continued heat, we find that all gypseous stones, and all the artificial selenitic salts, are fusible and vitrescible by violent fire.

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We may obſerve, that amongſt the various bodies called by chemiſts ſelenites, that is, compounds of vitriolic acid with calcareous earths, ſome differ much from others, at leaſt externally. Theſe ſubſtances are all the gypſums, alabaſters, and ſpars, which ſome chemiſts, particularly Mr. Pott, have called gypſeous, and, laſtly, ſome cryſtallizations and ſtalactites, which have the ſame principles and the ſame eſſential properties as other ſelenitic ſubſtances. *See* ACID (VITRIOLIC), ALABASTER, GYPSUM, SPAR, *and* EARTH (CALCAREOUS).

SEMI-METAL. Subſtances poſſeſſing all the metallic properties, excepting fixity and ductility, are called *ſemi-metals*. Thus every matter poſſeſſed of metallic denſity, opacity, and luſtre, which is incapable of uniting with earths, but which is alſo brittle and frangible by the ſtroke of a hammer, and capable of being ſublimed or reduced into vapors by fire, is a ſemi-metal. Hitherto we know but five ſemi-metals, which are *regulus of antimony*, *zinc*, *biſmuth*, *regulus of cobalt*, *and regulus of arſenic*.

Some chemiſts have numbered mercury amongſt the ſemi-metals, under pretence that it poſſeſſed all the metallic properties excepting fixity and ductility: but all ſemi-metals are combuſtible, and mercury is no more ſo than the perfect metals; and alſo, the want of ductility is falſely imputed to it, ſince the Academicians of Peterſbourg, who ſome years ago fixed it, found it ductile and malleable. If mercury then be not ductile in its ordinary ſtate, the cauſe of this appears to be, that it is really in fuſion: but the moſt ductile metals loſe their ductility by fuſion, as this quality neceſſarily implies ſolidity. On the other ſide, the great volatility of mercury does not allow us to claſs it among metals. This metallic ſubſtance is therefore ſingle in its kind, and is really neither a metal nor a ſemi-metal. *See* MERCURY.

Mr. Cronſtedt has given, in the Memoirs of the Swediſh Academy for the year 1751, a deſcription of a new ſemi-metal: but this metallic ſubſtance is hitherto but little known. *(f)*

*(f)* Concerning this new ſemi-metal diſcovered by Mr. Cronſtedt, *ſee the article* NICKEL. *See alſo a note to the article* METALS, concerning another new ſemi-metal which Mr. Juſti ſays that he has diſcovered in the yellow mica.

SENA. *(g)*
SENEGAL (GUM) *(h)*
SERPENTINE-STONE. *(i)*
SILK. *(k)*

SILVER. Silver, called alſo *luna* by chemiſts, is a perfect metal, of a ſhining white color.

Its ſpecific gravity is, although conſiderable, nearly one half leſs than that of gold. It loſes in water an eleventh part of its weight. A cubic foot of ſilver weighs 720 pounds.

The tenacity of its parts is alſo nearly one half leſs than that of gold; a ſilver wire, the diameter of which is $\frac{1}{10}$ part of an inch, can ſupport only a weight of 270 pounds without breaking.

This metal is, next to gold, the moſt ductile of all. Very fine wire and leaf may be formed of it.

It is ſomewhat ſonorous and harder than gold, as Juncker obſerves; and is fuſible with a leſs degree of heat than gold is, according to Cramer. It ſeems to be as fixed and indeſtructible as gold is. Kunckel kept ſilver and gold in a

*(g)* SENA. An ounce of the leaves of Sena, treated with freſh parcels of rectified ſpirit of wine, yielded two drams and twenty-three grains of reſinous extract; and afterwards with water, two drams and two ſcruples of gummy extract, three drams and three grains remaining undiſſolved. Another ounce, treated firſt with water, gave four drams and half a ſcruple of gummy, and afterwards with ſpirit only, twenty-eight grains of a reſinous extract, which appeared to contain ſome groſs oily matter; and hence was difficultly reduced to dryneſs. The reſiduum weighed three drams and a ſcruple. Water diſtilled from Sena poſſeſſes the peculiar ſmell of theſe leaves, but no eſſential oil appears. The activity of Sena is greatly weakened by evaporation, eſpecially if the proceſs be performed in an open veſſel with a boiling heat. *Neuman.*

*(h)* SENEGAL (GUM) is a gum, almoſt pure, and entirely ſimilar in properties to the other pure gums, as gum arabic, cherry-tree and plum-tree gums. *See* GUM.

*(i)* SERPENTINE STONE is a ſteatites variouſly colored, but in which the green color generally predominates. *See* STEATITES.

*(k)* SILK is an animal ſubſtance, from 16 oz. of which may be obtained, by diſtillation, nine ounces of mixed matters, containing four ounces and two drams of urinous ſpirit, three ounces ſix drams of volatile ſalt, and one ounce of empyreumatic oil. The caput mortuum weighed ſeven ounces, and loſt an ounce on being calcined to whiteneſs. By elixating the calx, forty grains of fixed ſaline matter were alſo obtained. *Neuman.*

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d, like some other metallic matters; but silver seems
more susceptible of this effect than any other metal.

All acids are, with more or less facility, capable of dissolving silver.

Vitriolic and marine acids may be combined with silver in its metallic state; but difficultly, and by particular management.

To dissolve silver directly, vitriolic acid must be much concentrated and very hot; and therefore distillation is necessary, as in the operation of turbith mineral. *See* TURBITH MINERAL.

The marine acid cannot attack silver directly; but when it is very much dephlegmated, and, as it were, in a dry state, considerably hot and reduced to vapor, as is done by the royal cement in *concentrated parting*. *See* PARTING (CONCENTRATED).

But silver may be combined with the above-mentioned acids, by methods much more simple and convenient, which we shall describe, after having spoken of the solution of silver by nitrous acid.

Nitrous acid, very pure and moderately strong, dissolves silver in its metallic state with the greatest facility. This solution is made spontaneously without heat, or with a very gentle heat at first; and when the silver has begun to dissolve, the heat ought to be discontinued, to prevent the so-

 lution

lution from being too violent, especially if the quantities operated upon be considerable.

By this method nitrous acid may be saturated with silver; and if it be strong, it will dissolve a considerable quantity of that metal.

If the silver thus dissolved be allayed with copper, the solution will be green, and will preserve this color. If it contain no copper, the solution is at first greenish, which color gradually dissipates, and at last the liquor becomes quite white.

The surface of the silver begins to become black as soon as the acid makes impression upon it. This blackness proceeds from a part of the phlogiston of the nitrous acid, which is applied superabundantly to the surface of the silver.

Black flocks are frequently seen floating in this solution, which are insoluble by nitrous acid, and precipitate to the bottom. These flocks may be a small quantity of gold from which silver is seldom entirely free, or of some other phlogisticated substance, insoluble in nitrous acid.

The solution of silver by nitrous acid is more acrid and corrosive than pure nitrous acid; which property is very remarkable, and is common to it with several other combinations of metals. *See an explanation of this property under the article* CAUSTICITY.

This solution of silver corrodes all vegetable and animal matters, and stains the skin of a black color, which cannot be effaced till the blackened part be abraded. This blackness can be only attributed to the phlogiston of corroded matters, which unites superabundantly with the silver of the solution employed.

If a solution of silver by nitrous acid be sufficiently evaporated, and left to cool, a large quantity of white crystals will be formed in it, like scales, which are commonly called *crystals of silver*. These crystals are a nitrous salt, the basis of which is silver; for which reason it may also be called *nitre with basis of silver*, or *lunar nitre*.

This salt is fusible with a small heat, and easily loses the water of its crystallization. It becomes black, congeals by cold, and is capable of being moulded. It is then the famous cautery used by surgeons, and known by the name of *lapis infernalis*. *See the words* PARTING, CRYSTALS *of* SILVER, *and* LAPIS INFERNALIS.

Lunar nitre deflagrates upon coals almost as well as the nitre with basis of fixed alkali, which shews a strong adhesion

ſion of nitrous acid with ſilver. Nevertheleſs, this ſalt expoſed to ſtrong fire in diſtilling veſſels, or in a crucible, may be eaſily decompoſed. The acid quits the ſilver, and appears in its former ſtate.

Although ſilver, as we have ſeen, is more eaſily ſoluble in nitrous acid than in vitriolic and marine acids, we ought not thence to conclude, that this metal has, with the nitrous acid, a greater affinity than with the two others. On the contrary, the two latter acids are capable of ſeparating it from the nitrous acid, after this has diſſolved it.

If vitriolic acid be poured into a ſolution of ſilver in nitrous acid, and if it be not diluted in too great a quantity of water, we ſee immediately the liquors become turbid, and a white precipitate appears, which is nothing elſe than a new combination made of the ſilver which quitted the nitrous acid to unite with the vitriolic acid, and to form with it a new ſalt with metallic baſis. This ſalt, which may properly be called *vitriol of ſilver*, or *lunar vitriol*, is cryſtallizable, and actually does cryſtallize in the very inſtant of precipitation; but the cryſtals are ſo ſmall, from the rapidity of the cryſtallization, that they have only the appearance of a white powder. They cannot be diſcovered to be cryſtals but by means of a good magnifying glaſs.

The ſame event happens, if, inſtead of vitriolic acid, a ſolution of any ſalt containing that acid be added to a ſolution of ſilver in nitrous acid. The nitre of ſilver will be thereby decompoſed, and a vitriol of ſilver obtained ſimilar to the former.

Although vitriolic acid engaged in any baſis, ſuch as fixed alkali, with which it has a ſtronger affinity than with ſilver, does nevertheleſs quit its baſis to combine with this metal, yet we may obſerve, that in theſe precipitations two decompoſitions and two new combinations are always effected, by means of a double affinity. We may therefore ſee the explanation of this caſe at the word AFFINITY.

Marine acid, whether engaged in any baſis, or diſengaged, produces in the ſolution of ſilver by nitrous acid the ſame effect as the vitriolic acid. It ſeparates from the nitrous acid the metal, with which it unites and forms a new compound, or a *marine ſalt with baſis of ſilver*, known to chemiſts by the name of *luna cornea*, or *corneous ſilver*. *See* LUNA CORNEA. It is called corneous, becauſe this ſilver, united with marine acid by expoſure to fire, may be melted; and may be coagulated by cold into a ſemi-tranſparent, ſemi-flexible maſs, like horn.

Luna cornea, although in a ſaline ſtate, is very little ſoluble by water. The precipitate which it forms is very apparent: it is compoſed of flocks, which adhere one to another, and form a kind of white curd, that floats in the liquor. By this appearance alone it may be diſtinguiſhed from vitriol of ſilver.

Theſe properties of a ſolution of ſilver, together with the facility with which it is rendered turbid by the preſence of the ſmalleſt quantity of vitriolic and marine acids, diſengaged or combined with any baſis, render it very convenient and much uſed for the examination of waters, and in other chemical operations, to aſcertain the preſence of theſe two acids, in whatever compound they may be contained.

Silver, as well as all metals, may be ſeparated from any acid by abſorbent earths, or by fixed and volatile alkalis; and when afterwards fuſed, it recovers its original properties. Silver, thus diſſolved, precipitated, and melted, is generally very pure. We may be certain that ſilver, which has been formed into luna cornea, and afterwards has been reduced, does not contain a particle of gold, platina, copper, iron, or other metallic ſubſtance ſoluble in aqua regia, and conſequently not ſeparable from nitrous acid by means of marine acid.

From what has been ſaid concerning theſe ſeveral decompoſitions of a ſolution of ſilver made by nitrous acid, we may infer that this combination may be decompoſed;

1. By the action of fire alone, which expels the nitrous acid.

2. By phlogiſton, which burns and deſtroys nitrous acid in the detonation of lunar nitre.

3. By precipitation with ſaline or earthy alkalis, which ſeize the nitrous acid, and leave the ſilver diſengaged in the ſtate of a precipitate.

4. By vitriolic acid, which ſeizes the ſilver, and leaves the nitrous acid diſengaged.

5. By marine acid, which has the ſame effect.

6. Laſtly, ſeveral metals, and eſpecially copper, having a ſtronger affinity than ſilver with nitrous acid, decompoſe alſo this ſolution of ſilver, by ſeizing the acid, and obliging the ſilver to ſeparate from it, which it does by precipitating it in its proper metallic ſtate. *See the words* PRECIPITATE *and* PRECIPITATION.

Sulphur diſſolves ſilver by fuſion, and forms with it a blackiſh maſs, which may be cut, and which has almoſt the color and conſiſtence of lead. It is called *ſulphurated ſilver*.

*silver.* This compound is a kind of artificial ore of silver. Some expert persons are said to be able to imitate very well by this mixture some natural ores of silver.

To make this combination, silver and sulphur are laid alternately upon each other in several strata in a crucible, which is to be heated by degrees till the whole be fused. Less heat is required for this fusion than if the silver was alone, because sulphur facilitates the fusion of this, as well as of all other metals difficultly fusible, upon which it is capable of acting.

The sulphur may be separated from the silver by the mere action of the fire, continued during a certain time with access of air. When sulphurated silver is detonated with nitre, this separation is very well and instantly made. As this metal is indestructible by all these agents, it is found to be unchanged by these operations.

Juncker relates, after Kunckel, that if sulphur be dissipated from sulphurated silver by the action of fire; and if a volatile alkaline spirit of urine be poured upon this silver, a blue color is produced. He adds also, that this does not happen a second time to the same silver, unless it be first cupelled with lead. This chemist concludes from thence, that this color proceeds from copper which the silver receives from the lead. *See Conspectus Chymiæ, Tom.* I. *p.* 893.

Silver is found within the earth in different states. A very small quantity of it is in its natural and malleable state, allayed with copper and gold; and is then called *virgin* or *native silver:* but silver is generally found in a mineral state, that is, united and incorporated with heterogeneous matters, such as other metallic substances, and the mineralising substances, namely, sulphur and arsenic. It is separated from all these matters by particular processes practised both in essays and in smelting the ore in large quantities. *See* ORES *of* SILVER.

Silver is purified from the allay of other destructible metals by treating it with nitre, or with lead. *See* PURIFICATION *of* SILVER *by* NITRE. The latter method is generally used by refiners, and is called *cupellation*, or *refining*. *See* REFINING.

All these operations are founded in general upon the destructibility of imperfect metals, and on the indestructibility of silver, which is a perfect metal: but as gold is an indestructible metal, all the purifications of silver, which are only effected by the destruction of metals allayed within it, are

ſufficient to ſeparate it from gold. We muſt therefore have recourſe to other operations, for the ſeparation of theſe two metals from each other. Theſe operations, which are called by the general name of *parting*, are founded upon the property which ſilver has of being ſoluble by many menſtrua which do not act upon gold. Theſe menſtrua are;

1. Nitrous acid, which diſſolves ſilver without touching gold. By means of this acid, ſilver is generally parted from gold, and the operation is called *parting*, without any epithet to diſtinguiſh it from the others. *See* PARTING.

2. Marine acid, which being applied conveniently to a mixture of gold and ſilver, ſeizes the latter metal excluſively of the former. As this parting is performed by cementation, and as the marine acid muſt be highly concentrated, it is called concentrated parting. *See* PARTING (CONCENTRATED).

3. Laſtly, ſulphur, which unites alſo to ſilver without touching gold, furniſhes a third method of ſeparating theſe two metals. This is called *dry parting*, becauſe it is made by fuſion, which chemiſts call the *dry way*. *See* PARTING (DRY).

Silver is capable of being allayed with all metals, and forms with them different compounds, the properties of which may be ſeen under the word ALLAY.

According to Mr. Geoffroy's Table of Affinities, thoſe of ſilver are firſt to lead, and then to copper; and Mr. Gellert's Table mentions only gold.

SIMILOR. This is a name given to an allay of red copper and zinc, made in the beſt proportions to imitate the color of gold. *See* COPPER, BRASS, *and* ZINC.

SMALT. It is a blue glaſs compoſed of the calx of cobalt, vitrified and melted with ſome fritt of glaſs or cryſtal. Ground ſmalt is called *azure*, or *enamel blue*. *See* AZURE, COBALT, *and* ZAFFRE.

SMELTING *of* ORES. We have ſhewn, under the articles ORES and PYRITES, the nature of the principal metallic minerals, and the ſubſtances of which they are compoſed. We have alſo explained, under the article ESSAY OF ORES, the proceſſes by which an exact analyſis of theſe compound minerals may be made, and the nature and quantity of the contained metals may be known. In order to complete what relates to this important ſubject, we ſhall deſcribe in this article the principal operations by which are obtained "in the great," as it is called, or for commercial purpoſes, metals, ſulphur, vitriols, and other uſeful

ful substances contained in metallic minerals. What we shall say upon this subject will chiefly be extracted from a *Treatise on the Smelting of Ores, by Schlutter*, translated from the German into French by *M. Hellot*; because this, of all the modern works upon that subject, appears to be the most exact. We shall first describe the operations upon pyritous matters for the extraction of sulphur, vitriols, and alum; and afterwards the operations by which metallic substances are extracted from ores properly so called; from which also are occasionally obtained the same matters as from the pyrites. As the present article is only the sequel of the articles ORES, PYRITES, and ESSAYS *of* ORES, it is evident that these articles ought to be read previously to this.

## EXTRACTION *of* SULPHUR *from* PYRITES *and other* MINERALS.

In order to obtain sulphur from pyrites, this mineral ought to be exposed to a heat sufficient to sublime the sulphur, or to make it distill in vessels, which must be close, to prevent its burning.

Sulphur is extracted from pyrites at a work at *Schwartzemberg*, in *Saxony*, in the high country of the mines; and in *Bohemia*, at a place called *Alten-Sattel*.

The furnaces employed for this operation are oblong, like vaulted galleries; and in the vaulted roofs are made several openings. These are called *furnaces for extracting sulphur*. *See* PLATE II. *Fig.* 9.

In these furnaces are placed earthen-ware tubes, filled with pyrites broken into pieces of the size of small nuts. Each of these tubes contains about fifty pounds of pyrites. They are placed in the furnace almost horizontally, and have scarcely more than an inch of descent. The ends, which come out of the furnace five or six inches, become gradually narrower. Within each tube is fixed a piece of baked earth, in form of a star, at the place where it begins to become narrower, in order to prevent the pyrites from falling out, or choaking the mouth of the tube. To each tube is fitted a receiver, covered with a leaden plate, pierced with a small hole to give air to the sulphur. The other end of the tube is exactly closed. A moderate fire is made with wood, and in eight hours the sulphur of the pyrites is found to have passed into the receivers.

The residuum of the pyrites, after the distillation, is drawn out at the large end, and fresh pyrites is put in its place.

place. From this residuum, which is called *burnings of sulphur*, vitriol is extracted; as we shall presently relate.

The eleven tubes into which were put, at three several distillations, in all nine quintals, or 900 pounds of pyrites, yield from 100 to 150 pounds of crude sulphur, which is so impure as to require to be purified by a second distillation.

This purification of crude sulphur is also done in a furnace in form of a gallery, in which five iron cucurbits are arranged on each side. These cucurbits are placed in a sloping direction, and contain about eight quintals and a half of crude sulphur. To them are luted earthen tubes, so disposed as to answer the purpose of capitals. The nose of each of these tubes is inserted into an earthen pot, called the *fore-runner*. This pot has three openings; namely, that which receives the nose of the tube; a second smaller hole, which is left open to give air; and a third in its lower part, which is stopped with a wooden peg. *See* PLATE II. *Fig.* 10.

When the preparations are made, a fire is lighted about seven o'clock in the evening, and is a little abated as soon as the sulphur begins to distill. At three o'clock in the morning, the wooden pegs, which stop the lower holes of the fore-runners, are for the first time drawn out, and the sulphur flows out of each of them into an earthen pot with two handles placed below for its reception. In this distillation the fire must be moderated and prudently conducted; otherwise less sulphur would be obtained, and it also would be of a grey color, and not of the fine yellow which it ought to have when pure. The ordinary loss in the purification of eight quintals of crude sulphur is, at most, one quintal.

When all the sulphur has flowed out, and has cooled a little in the earthen pots, it is cast into moulds made of beech tree, which have been previously dipt in water, and set to drain. As soon as the sulphur is cooled in the moulds, they are opened, and the cylinders of sulphur are taken out and put up in casks. These are called *roll-brimstone*.

As sulphur is not only in pyrites, but also in most metallic minerals, it is evident that it might be obtained by works in the great from the different ores which contain much of it, and from which it must be separated previously to their fusion: but as sulphur is of little value, the trou-

ble

ble of collecting it from ores is seldom taken. Smelters are generally satisfied with freeing their ores from it, by exposing them to a fire sufficient to expel it. This operation is called *torrefaction*, or *roasting of ores*.

There are, however, ores which contain so much sulphur, that part of it is actually collected in the ordinary operation of roasting, without much trouble for that purpose. Such is the ore of *Ramelsberg*, in the country of *Hartz*.

This ore, which is of lead, containing silver, is partly very pure, and partly mixed with cupreous pyrites and sulphur; hence it is necessary to roast it.

The roasting is performed by laying alternate strata of ore and wood upon each other in an open field, taking care to diminish the size of the strata as they rise higher; so that the whole mass shall be a quadrangular pyramid truncated above, whose base is about thirty-one feet square. Below, some passages are left open, to give free entrance to the air; and the sides and top of the pyramid are covered over with small ore, to concentrate the heat and make it last longer. In the center of this pyramid there is a channel, which descends vertically from the top to the base. When all is properly arranged, ladle-fulls of red-hot scoria from the smelting furnace are thrown down the channel, by which means the shrubs and wood, placed below for that purpose, are kindled, and the fire is from them communicated to all the wood of the pile, which continues burning till the third day. At that time the sulphur of the mineral becomes capable of burning spontaneously, and of continuing the fire after the wood is consumed.

When this roasting has been continued fifteen days, the mineral becomes greasy, that is, it is covered over with a kind of varnish: twenty or twenty-five holes, or hollows, are then made in the upper part of the pile, in which the sulphur is collected. From these cavities the sulphur is taken out thrice every day, and thrown into water. This sulphur is not pure, but crude, and is therefore sent to the manufacturers of sulphur to be purified in the manner above related. *See* PLATE II. *Fig.* 11. *and* 12.

As this ore of Ramelsberg is very sulphureous, the first roasting, which we are now describing, lasts three months; and during this time, if much rain has not fallen, or if the operation has not failed by the pile falling down or cracking, by which the air has so much free access, that the sulphur

ſulphur is burnt and conſumed, from ten to twenty quintals of crude ſulphur are by this method collected.

The ſulphur of this ore, like that of moſt others, was formerly neglected, till, in the year 1570, a perſon employed in the mines, called Chriſtopher Sauder, diſcovered the method of collecting it, nearly as it is done at preſent.

Metallic minerals are not the only ſubſtances from which ſulphur is extracted. This matter is diffuſed in the earth in ſuch quantities, that the metals cannot abſorb it all. Some ſulphur is found quite pure, and in different forms, principally in the neighbourhood of volcanos, in caverns, and in mineral waters. Such are the opake kind called *virgin ſulphur*, the tranſparent kind called *ſulphur of Quito*, and the native flowers of ſulphur, as thoſe of the waters of Aix-la-Chapelle. It is alſo found mixed with different earths. Here we may obſerve, that all thoſe kinds of ſulphur which are not mineraliſed by metallic ſubſtances, are found near volcanos, or hot mineral waters, and conſequently in places where nature ſeems to have formed great ſubterranean laboratories, in which ſulphureous minerals may be analyſed and decompoſed, and the ſulphur ſeparated, in the manner in which it is done in ſmall in our works and laboratories. However that be, certainly one of the beſt and moſt famous ſulphur mines in the world is that called *Solfatara*. The Abbé Nollet has publiſhed, in the Memoirs of the Academy, ſome intereſting obſervations upon this ſubject, which we ſhall here abridge.

Near Puzzoli, in Italy, is that great and famous mine of ſulphur and alum called at preſent *Solfatara*. It is a ſmall oval plain, the greateſt diameter of which is about 400 yards, raiſed about 300 yards above the level of the ſea. It is ſurrounded by high hills and great rocks, which fall to pieces, and whoſe fragments form very ſteep banks. Almoſt all the ground is bare and white, like marle, and is every where ſenſibly warmer than the atmoſphere in the greateſt heat of ſummer; ſo that the feet of perſons walking there are burnt through their ſhoes. It is impoſſible not to obſerve the ſulphur there; for every where may be perceived by the ſmell a ſulphureous vapor, which riſes to a conſiderable height, and gives reaſon to believe that there is a ſubterraneous fire below, from which that vapor proceeds.

Near

Near the middle of this field there is a kind of bason three or four feet lower than the rest of the plain, in which a sound may be perceived when a person walks on it, as if there were under his feet some great cavity, the roof of which was very thin. After that, the lake Agnano is perceived, whose waters seem to boil. These waters are indeed hot, but not so hot as boiling water. This kind of ebullition proceeds from vapors which rise from the bottom of the lake, which being set in motion by the action of subterranean fires, have force enough to raise all that mass of water. Near this lake there are pits, not very deep, from which sulphureous vapors are exhaled. Persons who have the itch, come to these pits, and receive the vapors in order to be cured. Finally, there are some deeper excavations, whence a soft stone is procured which yields sulphur. From these cavities vapors exhale, and issue out with noise, and which are nothing else than sulphur subliming through the crevices. This sulphur adheres to the sides of the rocks, where it forms enormous masses: in calm weather the vapors may be evidently seen to rise 25 or 30 feet from the surface of the earth.

These vapors, attaching themselves to the sides of rocks, form enormous groups of sulphur, which sometimes fall down by their own weight, and render these places of dangerous access.

In entering the Solfatara, there are warehouses and buildings erected for the refining of sulphur.

Under a great shed, or hangar, supported by a wall behind, open on the other three sides, the sulphur is procured by distillation from the soft stones we mentioned above. These stones are dug from under ground; and those which lie on the surface of the earth are neglected. These last are, however, covered with a sulphur ready formed, and of a yellow color: but the workmen say they have lost their *strength*, and that the sulphur obtained from them is not of so good a quality as the sulphur obtained from the stones which are dug out of the ground.

These last mentioned stones are broken in lumps, and put into pots of earthen ware, containing each about twenty pints, Paris measure. The mouths of these pots are as wide as their bottoms; but their bellies, or middle parts, are wider. They are covered with a lid of the same earth, well luted, and are arranged in two parallel lines along two brick walls, which form the two sides of a furnace. The pots are placed within these walls; so that the center of

of each pot is in the center of the thickness of the wall and that one end of the pots overhangs the wall within, while the other end overhangs the wall without. In each furnace ten of these pots are placed; that is, five in each of the two walls which form the two sides of the furnace. Betwixt these walls there is a space of fifteen or eighteen inches; which space is covered by a vault resting on the two walls. The whole forms a furnace seven feet long, two feet and a half high, open at one end, and shut at the other, excepting a small chimney, through which the smoke passes.

Each of these pots has a mouth in its upper part without the furnace, in order to admit a tube of eighteen lines in diameter and a foot in length, which communicates with another pot of the same size placed without the building, and pierced with a round hole in its base of fifteen or eighteen lines diameter. Lastly, to each of these last mentioned pots there is a wooden tub placed below, in a bench made for that purpose.

Four or five of these furnaces are built under one hangar or shed. Fires are kindled in each of them at the same time; and they are thrown down after each distillation, either that the pots may be renewed, or that the residuums may be more easily taken out.

The fire being kindled in the furnace, heats the first pots containing the sulphureous stones. The sulphur rises in fumes into the upper part of the pot, whence it passes through the pipe of communication into the external vessel. There the vapors are condensed, become liquid, and flow through the hole below into the tub, from which the sulphur is easily turned out, because the form of the vessel is that of a truncated cone, whose narrower end is placed below, and because the hoops of the tub are so fastened that they may be occasionally loosened. The mass of sulphur is then carried to the buildings mentioned before, where it is remelted for its purification, and cast into rolls, such as we receive it.

## EXTRACTION *of* VITRIOL *from* PYRITES.

Sulphur is not the only substance procured from pyrites; for besides that, different kinds of vitriols and alum, according to the nature of pyrites, are also extracted: so that pyrites may be considered as the ores of vitriols and alum as well as of sulphur.

These

These salts do not exist in the pyrites ready formed, as the sulphur does; but are, on the contrary, the products of the decomposition of pyrites, and are new combinations resulting from this decomposition. In the pale-yellow martial pyrites, this decomposition is effected without any other means than by exposure to moisture and air, and by the re-action of the sulphureous principle upon the iron which the pyrites contains, and with which the acid of the sulphur forms martial vitriol, as we may see under the article PYRITES. When the vitriol of this pyrites is to be extracted, this mineral is to be laid in a large heap three feet thick, and exposed to the air during three years, till it has entirely fallen into powder; and it is then to be stirred up every six months to accelerate the efflorescence. The rain-water, which has washed it, is to be conducted into caldrons, into which old iron is thrown to saturate the superfluous acid. After this succeeds the evaporation and crystallization.

It is not necessary that the pyrites should fall into efflorescence for the extraction of vitriol. The action of the fire which decomposes one part of the sulphur produces the same effect. Thus, in the works at Schwartzemberg in Upper Saxony, the vitriol is extracted, by lixiviating the pyrites after the distillation of the sulphur, which is called in some works, as we have before said, the *burnings of sulphur*, and which are in this work called *sulphur-brands*. This operation consists in impregnating well the lixivium with vitriol, by pouring it upon fresh parcels of these sulphur-brands, which is called doubling the lixivium: then it is evaporated in a leaden caldron, called the *sulphur-caldron*; and afterwards it is crystallized in a wooden vessel. The sulphur-brands, from which vitriol has been extracted, are not thereby exhausted; but they are exposed to the open air for two years, and are then again lixiviated for the extraction of more vitriol.

Vitriol is also made at *Geyer*, in Upper Saxony. The difference betwixt the method employed there and at Schwartzemberg, is, that at Geyer the pyrites has not been used for the extraction of sulphur by distillation, but has been roasted fifteen days, and afterwards lixiviated. The lixivium is evaporated in leaden caldrons, and afterwards put in shallow tubs called coolers, where it deposites a yellow mud. The evaporation and depuration of this lixivium lasts twenty-four hours, and then the liquor is put into tubs to crystallize.

The

The pyrites, which has been roasted and lixiviated once at Geyer, is not thereby exhausted; but is made to undergo the same operation four or five times, by which it furnishes more vitriol. The yellow mud which is deposited from the lixivium is sold, as a coloring material, to painters, after it has been calcined to redness.

Nature furnishes a vitriol ready formed in some mineral earths, to obtain which vitriol, nothing but lixiviation is necessary. Such is that vitriol obtained at Cremnitz, where there is a rich ore of gold. The vitriol is there extracted merely for the purpose of preparing aqua-fortis, which is necessary in the operation for parting the gold contained in that ore. In the neighbourhood of Cremnitz, a soft rock and clay are found, containing vitriol, and which furnish it by means of lixiviation.

To this kind of vitriol ready formed may be referred that obtained at Goslar by the lixiviation of a mineral earth, composed of particles of different ores, found in the galleries of the mine at Ramelsberg, of which we have already spoken. The workmen call this substance the *smoke of copper*. It requires lixiviation only to furnish vitriol. It is true, that by the wood-fires made in these galleries to calcine the rocks, the metallic matters may be disengaged, and a part of the sulphur burnt, the acid of which, mixing with the subterranean waters, dissolves all the metallic matters it meets, and forms all kinds of vitriols. Nevertheless, some of these vitriolic waters, and even some crystallized vitriols, are found in these galleries, where no fire is ever made. The Germans call all these vitriols by the general name *Jockels*. Some vitriols are also found not crystallized, but forming various colored stones, which furnish vitriol by lixiviation. They are called *ink-stones*. What is called *misy* is a yellow, shining, vitriolic stone or earth, found in the same places.

To return to the substance called smoke of copper, whence the martial vitriol is extracted at Goslar; several lixiviums are made of it, by pouring the same water upon different parcels of it: it is then made to evaporate, to deposite its sediment, and to crystallize, as we have already said. The first water is called the *wild ley*. The several vessels employed at Goslar are named from their several uses, as the *washing tub*, *mud tub*, &c.

This substance remaining after the lixiviation of this smoke of copper, is a kind of ore not entirely deprived of metallic substances. The workmen call the finest part of it

*small*

*ſmall vitriol*, and the larger pieces they call *ſtones*, or *kernels of vitriol*. Both theſe are carried to the ſmelting houſes to be roaſted and melted with the Rammelſberg ore, that the lead and ſilver, which they contain, as well as that ore, may be extracted.

A white vitriol, whoſe baſis is zinc, is alſo procured at Goſlar from the ſame Rammelſberg ore. This vitriol was diſcovered in the year 1570 by the Duke Julian, who called it *alum of the mine*. At preſent it is known by the names, *white vitriol*, *vitriol of zinc*, *Goſlar vitriol*.

To make this vitriol, the ore of Rammelſberg, containing lead and ſilver, having been previouſly roaſted for the obtaining of ſulphur, as we have already deſcribed, undergoes the ſame operations which are practiſed for the preparation of martial vitriol, excepting the formation of large cryſtals, which is here purpoſely prevented, by liquefying the vitriol after it is formed in copper caldrons. This liquefaction is effected by means of the water retained in the cryſtallization of the vitriol. While the vitriol is liquefied, a part of the moiſture is evaporated, and women employed in this work keep ſtirring it till it has acquired the requiſite conſiſtence. By this ſtirring, it is divided into very fine cryſtalline particles, and it acquires the whiteneſs of the fineſt ſugar; a quality which makes it ſaleable, and which is procured by the means above related, and by carefully making it depoſite the ferruginous matter with which theſe lixiviums are always impregnated.

As to the blue vitriol, or vitriol of copper, it is extracted from the cupreous pyrites, or even from ſulphureous copper ores, by the operations already mentioned. Frequently the ferruginous pyrites and minerals alſo contain copper: and therefore the vitriol extracted from them is half martial and half cupreous, and is of a ſea-green color.

## EXTRACTION *of* ALUM *from* PYRITOUS SUBSTANCES *and from* ALUMINOUS EARTHS.

One part of the unmetallic earth which is always in pyrites, and in other metallic and ſulphureous minerals, is ſometimes of that kind of earths which are ſoluble in acids, and particularly of the nature of that earth which is the baſis of alum.

When the pyrites contains ſome of this kind of earth, the acid of its ſulphur being diſengaged either by the efflo-

rescence of the pyrites, or by its calcination and combustion, ought to unite itself as readily, and even more so, to this earth than to the metals contained in the same pyrites, and form a true alum: accordingly so it happens, and alum is extracted from pyrites or other sulphureous minerals containing this earth, by processes similar to those employed for the extraction of vitriols.

In England, a pyritous, slate-colored, sulphureous stone is found, from which alum is extracted by torrefaction and lixiviation; but to this lixivium a certain quantity of fossile alkali, dissolved in water, is generally added.

The Swedes have a shining pyrites of a golden color, and speckled with silvery spots, from which they extract sulphur, vitriol, and alum. Sulphur and vitriol are extracted from it by the methods we have described; and when the lixivium yields no more crystals of vitriol, an eighth part of putrefied urine and lixivium of wood-ashes is added, by which a martial earth is precipitated: the liquor being poured off, crystals of alum are obtained by evaporation.

Finally, it appears that in general, when alum is to be extracted from sulphureous and metallic minerals, fine and pure crystals cannot be without some difficulty obtained. It is almost always necessary to have recourse to some additions of alkaline matters, such as quicklime, and fixed or volatile alkaline salts.

These difficulties proceed partly from this, that different kinds of salts are formed at the same time by the decomposition of these minerals; and that these salts are crystallized by nearly the same degrees of evaporation and cold: hence a confusion of salts must necessarily follow: and hence we do not find many of the vitriols, extracted from such minerals, perfectly pure and free from alum, or from vitriolic salts with earthy bases similar to alum. The *salt of colcothar* and the *gilla vitrioli* are nothing else than these foreign salts. On the other hand, the alum which is extracted from metallic minerals contains almost always some vitriol, and particularly martial vitriol. *(l)*

But there are unmetallic earths and stones which contain alum, or its materials, ready formed. Such is that earth

*(l)* From Mr. Margraaf's experiments, an addition of some alkaline substance seems to be always necessary to the formation of large crystals of alum, however free the lixivium is from the mixture of vitriols or other salts. *See a note subjoined to the article* ALUM (ROMAN).

whence

whence alum is extracted at Solfatara. This mineral is an earth similar to marle in consistence and color. It is gathered in the plain, and in the western part of the Solfatara. It is put into leaden caldrons two feet and a half in diameter, and as much in depth, till these vessels be three quarters full. The caldrons are sunk so as to be almost level with the ground, under a great hangar or shed, at a distance of four hundred paces from the sulphur furnaces. Into each caldron water is poured till it rise three or four inches above the mineral. The heat of the ground in this place is sufficient to warm the matter, as it makes Mr. Reaumur's thermometer rise to $37\frac{1}{2}$ degrees above the freezing point. By this means, without the expence of wood, the saline part is separated from the earthy, and is obtained in large crystals.

Alum in this state is still mixed with many impurities, and is carried to the building at the entry of the Solfatara, where it is dissolved by hot water in a great stone vessel in form of a funnel. The purification of alum may be made so much more advantageously in this place, as no wood is necessary, the natural heat of the place being sufficient for the process.

To this kind of natural alum may be referred that which is obtained merely by evaporation from some mineral waters; and also the Roman alum which is obtained from a kind of free-stone, although a calcination during twelve or fourteen hours, and an exposition to the air till it falls into efflorescence be necessary. This stone is not pyritous, but rather of the marle kind: therefore its efflorescence is probably nothing more than an extinction, and differs essentially from the efflorescence of pyrites.

Such are the processes by which sulphur, vitriol, and alum are obtained from minerals containing these substances.

These minerals contain a great quantity of vitriolic acid, which chemists can separate from them; and they are, as it were, the grand magazines where nature deposites this acid, which is always found combined, as we have seen, with some substance or basis.

## SMELTING *of* ORES *in general.*

As ores consist of metallic matters combined with sulphur and arsenic, and are besides intermixed with earthy and stony substances of all kinds, the intention of all the operations upon these compound bodies is to separate these

different ſubſtances from each other. This is effected by ſeveral operations founded on the known properties of thoſe ſubſtances. We now proceed to give a general idea of theſe ſeveral operations.

Firſt of all, the ore is to be ſeparated from the earths and ſtones accidentally adherent to it; and when theſe foreign ſubſtances are in large maſſes, and are not very intimately mixed in ſmall particles with the ore, this ſeparation may be accompliſhed by mechanical means. This ought always to be the firſt operation, unleſs the adherent ſubſtance be capable of ſerving as a flux to the ore. If the unmetallic earths be intimately mixed with the ore, this muſt neceſſarily be broken and divided into ſmall particles. This operation is performed by a machine which moves peſtles, called bocards, or ſtampers. After this operation, when the parts of the mineral are ſpecifically heavier than thoſe of the unmetallic earth or ſtone, theſe latter may be ſeparated from the ore by waſhing in canals through which water flows. With regard to this waſhing of ores, it is neceſſary to obſerve, that it cannot ſucceed but when the ore is ſenſibly heavier than the foreign matters. But the contrary happens frequently, as well becauſe quartz and ſpar are naturally very ponderous, as becauſe the metallic matter is proportionably ſo much lighter as it is combined with more ſulphur.

When an ore happens to be of this kind, it is neceſſary to begin by roaſting it, in order to deprive it of the greateſt part of its ſulphur.

It happens frequently that the pyritous matters accompanying the ore are ſo hard that they can ſcarcely be pounded. In this caſe it is neceſſary to roaſt it entirely, or partly, and to throw it red-hot into cold water; by which the ſtones are ſplit, and rendered much more capable of being pulveriſed.

Thus it happens very frequently, that roaſting is the firſt operation to which an ore is expoſed.

When the ſubſtance of the ore is very fuſible, this firſt operation may be diſpenſed with, and the matter may be immediately fuſed, without any previous roaſting, or at leaſt with a very ſlight one. For, to effect this fuſion, it is neceſſary that it retain a great quantity of its ſulphur, which, with the other fluxes added, ſerves to deſtroy or convert into ſcoria a conſiderable part of the ſtony matter of the mineral, and to reduce the reſt into a brittle ſubſtance, which is called the *matt of lead*, or of *copper*, or other metal contained in the ore. This matt is therefore

ral and the metal;
d mixed with less
. But as this matt is
ch it contains cannot
refore it must be roasted
ur, before it is remelted,
. This fusion of an ore not
is called *crude fusion.*
the subject of washing and
ic is heavier than sulphur, and
metals, the ores in which it
y heavy, and consequently are
d, which is a great advantage.
s arsenic is capable of volatilising,
ing many metals, these ores have
roasting and fusion, in both which
caused by the arsenic. Some ores con-
, other volatile semi-metals, such as an-
. These are almost untractable, and are
ed. They are called *mineræ rapaces*, rapa-

metal has been freed as much as is possible
matters by these preliminary operations, it
mpleatly purified by fusions more or less fre-
repeated; in which proper additions are made,
absorb the rest of the sulphur and arsenic, or to
t the vitrification or scorification of the unmetallic
and earth.
ly, as ores frequently contain several different metals,
are to be separated from each other by processes suited
the properties of these metals, of which we shall speak
ore particularly as we proceed in our examination of the
res of each metal. *(m)*

OPERA-

*(m)* To facilitate the extraction of metallic substances from the ores and minerals containing them, some operations previous to the fusion or smelting of these ores and minerals are generally necessary. These operations consist of, 1. The *separation* of the ores and metallic matters from the adhering unmetallic earths and stones, by hammers, and other mechanical instruments; and by washing with water. 2. Their *division* or reduction into smaller parts by contusion and trituration, that by another washing with water they may be more perfectly cleansed from extraneous matters, and rendered fitter for the subsequent operations, calcination or roasting, and fusion. 3. *Roasting* or *calcination*, the

## OPERATIONS *on* ORES *of* NATIVE GOLD *and* SILVER, *by* WASHING *and by* MERCURY.

Earths and ſand are at firſt ſeparated by waſhing with water, by which operation the greateſt part of what is not gold,

the uſes of which operation are, to expel the volatile, uſeleſs, or noxious ſubſtances, as water, vitriolic acid, ſulphur, and arſenic; to render the ore more friable and fitter for the ſubſequent contuſion and fuſion; and, laſtly, to calcine and deſtroy the viler metals; for inſtance, the iron of copper-ores, by means of the fire, and of the ſulphur and arſenic. Stones, as quartz, and flints, containing metallic veins or particles, are frequently made red-hot, and then extinguiſhed in cold water, that they may be rendered ſufficiently friable and pulverable, to allow the ſeparation of the metallic particles.

Roaſting is unneceſſary for native metals; for ſome of the richer gold and ſilver ores; for ſome lead-ores, the ſulphur of which may be ſeparated during the fuſion; and for many calciform ores, as theſe do not generally contain any ſulphur and arſenic.

In the roaſting of ores, the following attentions muſt be given, 1. To reduce the mineral previouſly into ſmall lumps, that the ſurface may be encreaſed; but they muſt not be ſo ſmall, nor placed ſo compactly, as to prevent the paſſage of the air and flame. 2. The larger pieces muſt be placed at the bottom of the pile, where the greateſt heat is. 3. The heat muſt be gradually applied, that the ſulphur may not be melted, which would greatly retard its expulſion; and that the ſpars, fluors, and ſtones, intermixed with the ore, may not crack, fly and be diſperſed. 4. The ores not thoroughly roaſted by one operation muſt be expoſed to a ſecond. 5. The fire may be encreaſed towards the end, that the noxious matters more ſtrongly adhering may be expelled. 6. Fuel which yields much flame, as wood and foſſil coals free from ſulphur, is ſaid to be preferable to charcoal or coaks. Sometimes cold water is thrown on the calcined ore at the end of the operation, while the ore is yet hot, to render it more friable.

No general rule can be given concerning the duration or degree of the fire, theſe being very various according to the difference of the ores. A roaſting during a few hours or days is ſufficient for many ores; while ſome, ſuch as the ore of Rammelſberg, require that it ſhould be continued during ſeveral months.

Schlutter enumerates five methods of roaſting ores. 1. By conſtructing a pile of ores and fuel placed in alternate ſtrata, in the open air, without any furnace. *See* PLATE II. *Fig.* 11. *and Fig.*

gold, being lighter, is carried off. After this a second washing is made with mercury, which having the property of

*Fig.* 12. 2. By confining such a pile within walls, but without a roof. 3. By placing the pile under a roof, without lateral walls. 4. By placing the pile in a furnace consisting of walls and a roof. 5. By roasting the ore in a reverberatory furnace, in which it must be continually stirred with an iron-rod.

Several kinds of *fusions of ores* may be distinguished. 1. When a sulphureous ore is mixed with much earthy matter, from which it cannot be easily separated, by mechanical operations, it is frequently melted, in order to disengage it from these earthy matters, and to concentrate its metallic contents. By this fusion, some of the sulphur is dissipated, and the ore is reduced to a state intermediate betwixt that of ore and of metal. It is then called a *matt (lapis sulphureo-metallicus)*, and is to be afterwards treated like a pure ore by the second kind of fusion, which is properly the *smelting*, or *extraction of the metal by fusion*. 2. By this fusion or smelting, the metal is extracted from the ore previously prepared by the above operations, if these be necessary. The ores of some very fusible metals, as of bismuth, may be smelted by applying a heat sufficient only to melt the metals, which are thereby separated from the adhering extraneous matters. This separation of metals by fusion, without the vitrification of extraneous matters, may be called *eliquation*. Generally, a compleat fusion of the ore and vitrification of the earthy matters are necessary for the perfect separation of the contained metals. By this method, metals are obtained from their ores, sometimes pure, and sometimes mixed with other metallic substances, from which they must be afterwards separated; as we shall see, when we treat of the extraction of particular metals. To procure this separation of metals from ores, these must be so thinly liquefied, that the small metallic particles may disengage themselves from the scoria; but it must not be be so thin as to allow the metal to precipitate before it be perfectly disengaged from any adhering extraneous matter, or to pervade and destroy the containing vessels and furnace. Some ores are sufficiently fusible; but others require certain additions called *fluxes*, to promote their fusion, and the vitrification of their unmetallic parts; and also to render the scoria sufficiently thin to allow the separation of the metallic particles.

Different fluxes are suitable to different ores, according to the quality of the ore, and of the matrix, or stone adherent to it.

The matrixes of two different ores of the same metal frequently serve as fluxes to each other; as, for instance, an argillaceous matrix with one that is calcareous; these two earths being disposed to vitrification when mixed, though each of them is singly unfusible. For this reason, two or more different ores to be smelted are frequently mixed together.

of uniting with gold, ſeizes this metal, amalgamates with it, and ſeparates it exactly from the earthy matters, with all which it can form no union.

The

The ores alſo of different metals require different fluxes. Thus calcareous earth is found to be beſt ſuited to iron-ores, and ſpars and ſcoria to fuſible ores of copper.

The fluxes moſt frequently employed in the ſmelting of ores are calcareous earth, fluors or vitreous ſpars, quartz and ſand, fuſible ſtones, as ſlates, baſaltes, the ſeveral kinds of ſcoria, and pyrites.

*Calcareous earth* is uſed to facilitate the fuſion of ores of iron, and of ſome of the poorer ores of copper, and, in general, of ores mixed with argillaceous earths, or with feltſpar. This earth has been ſometimes added with a view of ſeparating the ſulphur, to which it very readily unites: but by this union, the ſulphur is detained, and a hepar is formed, which readily diſſolves iron and other metals, and ſo firmly adheres to them, that they cannot be ſeparated without more difficulty than they could from the original ore. This addition is therefore not to be made till the ſulphur be previouſly well expelled.

*Fluors* or *fuſible ſpars* facilitate the fuſion of moſt metallic minerals, and alſo of calcareous and argillaceous earths, of ſteatites, aſbeſtus, and of ſome other unfuſible ſtones, but not of ſiliceous earths without a mixture of calcareous earth.

*Quartz* is ſometimes added in the fuſion of ferruginous copper ores, the uſe of which is ſaid chiefly to be, to enable the ore to receive a greater heat, and to give a more perfect vitrification to the ferruginous ſcoria.

The *fuſible ſtones*, or *ſlates*, *baſaltes*, are ſo tenacious and thick when fuſed, that they cannot be conſidered properly as fluxes, but as matters added to leſſen the too great liquidity of ſome very fuſible minerals.

The *ſcoria* obtained in the fuſion of an ore is frequently uſeful to facilitate the fuſion of an ore of the ſame metal, and ſometimes even of ores of other metals.

*Sulphurated pyrites* greatly promote the fuſibility of the ſcoria of metals, from the ſulphur it contains. It is chiefly added to difficultly fuſible copper ores, to form the ſulphureous compounds called *matts*, that the ores thus brought into fuſion may be ſeparated from the adhering earthy matters, and that the ferruginous matter contained in them may be deſtroyed, during the ſubſequent calcination and fuſion, by means of the ſulphur.

As in the ores called *calciform*, the metallic matter exiſts in a calcined ſtate; and as calcination reduces the metals of mineraliſed ores (excepting the perfect metals) to that ſtate alſo; therefore all calciform and calcined ores require the addition of ſome

*fu-*

The mercury thus charged with gold is preſſed through ſhamoy leather, and the gold is retained united with a part of the mercury, from which it may be eaſily diſengaged by expoſure to a proper degree of heat, which diſſipates and evaporates the mercury, while the gold, being fixed, remains.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru belonging to the Spaniards. Theſe operations conſiſt in waſhings, triturations, and amalgams in the great, by help of machines. We ſhall not enter into theſe details, becauſe they rather belong to mechanics than to chemiſtry. They who are deſirous to know them, may conſult a work written by Alonzo Barba on this ſubject.

The ores of native ſilver are much rarer and leſs abundant than thoſe of gold. But if any of this kind were found ſufficiently rich, they might be treated with mercury exactly in the ſame manner as the ores of native gold. *(n)*

SMELT-

*inflammable ſubſtance* to reduce them to a metallic ſtate. In great works, the charcoal or other fuel uſed to maintain the fire produces alſo this effect.

*Metals* are ſometimes added in the fuſion of ores of other more valuable metals, to abſorb from theſe ſulphur or arſenic. Thus iron is added to ſulphurated cupreous and ſilver ores. Metals are alſo added in the fuſion of ores of other more valuable metals, to unite with and collect the ſmall particles of theſe diſperſed through much earthy matter, and thus to aſſiſt their precipitation. With theſe intentions, lead is frequently added to ores and minerals containing gold, ſilver, or copper.

*Ores of metals* are alſo ſometimes added to aſſiſt the precipitation of more valuable metals. Thus antimony is frequently added to aſſiſt the precipitation of gold intermixed with other metallic matters. *See purification of gold by antimony.* Thus far of ſmelting of ores in general.

*(n)* Gold is frequently contained in the ores of other metals, either in a native or mineraliſed ſtate, and in ſands, eſpecially thoſe which are black and ferruginous. *See* ORES *of* GOLD.

If *gold be contained in ores of other metals,* theſe metals together with the gold may be firſt extracted by the ordinary proceſſes for ſmelting theſe ores; and the gold may be then ſeparated from the metallic maſs thus obtained, by mixing and fuſing this maſs with a quantity of lead, and by the proceſs of cupellation, deſcribed in the articles ESSAY *of the* VALUE *of* SILVER, *and* REFINING. Generally, the operations for obtaining gold from ores of imperfect

## SMELTING *of* ORES *of* SILVER.

As ſilver, even in its proper ores, is always allayed with ſome other metals from which it is intended to be ſeparated, after that the ſilver ore has been well roaſted, it muſt be mixed with a greater or leſs quantity of lead previous to its fuſion.

Lead has the ſame effect in fuſion of gold and ſilver as mercury has upon theſe metals by its natural fluidity; that is to ſay, it unites with them, and ſeparates them from unmetallic matters, which, being lighter, riſe always to the ſurface. But lead has the further advantage of procuring, by its own vitrification, that of all metallic ſubſtances, excepting gold and ſilver. Hence it follows, that when gold and ſilver are obtained by means of mercury, they ſtill remain allayed with other metallic ſubſtances; whereas when they are obtained by fuſion and ſcorification with lead, they are then pure, and are not allayed with any metals, but with each other.

In proportion as the lead, which has been united to the gold and ſilver of the ore, is ſcorified by the action of the fire, and promotes the ſcorification of the other metallic matters,

fect metals are preciſely the ſame as thoſe for obtaining ſilver, to which therefore we refer. Moſt frequently a quantity of ſilver alſo is contained in theſe ores; and in this caſe the perfect metal obtained by cupellation is an allay of gold and ſilver, which muſt be afterwards ſeparated by the proceſſes called *parting*. *See* PARTING.

Many trials have been made to procure the ſmall quantity of gold contained in the *ferruginous ſands*, at a moderate expence (*See* ORES *of* GOLD); but as no work of this kind is now eſtabliſhed, we may preſume they have not been ſucceſsful. The beſt eſſays of this kind have been made, according to Schlutter, in the following manner.

The ſand is to be made red-hot, and extinguiſhed in cold water four times, by which its color is changed from the original yellow, red, or black, to a reddiſh brown. It is obſerved to emit, during the firſt and ſecond calcinations, an arſenical ſmell; and this ſmell may be produced again in the following calcinations by adding ſome inflammable matter. Let an ounce of the calcined ſand be mixed with two ounces of granulated lead, and one ounce of black flux, and put into a Heſſian crucible, with half an ounce of decrepitated ſea-ſalt upon the ſurface of the mixture. The crucible is to be placed in a good blaſt furnace, and a ſtrong

matters, it separates the perfect metals, and carries with it all the others to the surface. There it meets the unmetallic substances, which it likewise vitrifies, and which it changes into a perfect scoria, fluid, and such as a scoria ought to be to admit all the perfect metal contained in it to precipitate.

When all the heterogeneous matters have been thus disengaged by scorification with lead, the perfect metals, to which some lead still remains united, are to be further purified by the ordinary operation of the cupel.

The common rule for the fusion and scorification of silver ore with lead, is to add to the ore a quantity of lead so much greater as there is more matter to be scorified, and as these matters are more refractory and of more difficult fusion. Silver ores, or those treated as such, are often rendered refractory by ferruginous earths, pyritous matters, or cobalts, containing always a considerable quantity of an earth which is unmetallic, very subtle, and very refractory, and which renders a considerable augmentation of the quantity of lead necessary.

The quantity of lead which is commonly added to fusible silver-ores, that do not contain lead, is eight times

strong fire is to be excited. The matter contained in the crucible is to be frequently stirred with an iron-rod, and the heat is to be continued till the scoria is thin and perfectly fused. When the crucible is broken, a regulus of lead will be found, containing the gold and silver of the sand. By this method Mr. Leberecht obtained, in eleven essays, from 840 to 844 grains of perfect metal from a quintal of sand. Of the perfect metal obtained, from a fourth to a third part was gold. Some parcels of sand have yielded more than a thousand grains, and some not more than 350 grains per quintal. Instead of the granulated lead, and the black flux, which is too expensive for great operations, some have added, to an ounce of the sand, two ounces of litharge and a little powder of charcoal, by which they have obtained the same quantity of perfect metal. The scoria in these essays has been always found to contain some perfect metal.

The Hungarian copper ores, from which gold and silver are profitably extracted, contain a less quantity of these perfect metals than many ferruginous sands. But they may be formed into a matt, by fusion with pyrites, of which treatment the sands are incapable. From this matt, the gold and silver, along with the copper of the ore, may be precipitated, and separated from the sulphur of the pyrites, by addition of iron, which being more disposed than the other metals to unite with sulphur, disengages these metals, and allows them to precipitate.

the

the quantity of the ore. But when the ore is refractory, it is necessary to add twelve times the quantity of lead, and even more; also glass of lead, and fluxes, such as the white and black fluxes; to which however borax and powder of charcoal are preferable, on account of the liver of sulphur formed by these alkaline fluxes.

It is necessary to observe, that saline fluxes are only used in small operations, on account of their dearness. To these are substituted, in the great operations, of which we now treat, sandiver, fusible scoria, and other matters of little value.

The greatest part of the silver now employed in commerce is not obtained from the proper ores of silver, which are very scarce, but from lead, and even copper ores, which are more or less rich in silver. To give an idea of the manner of treating these kinds of ores, from which silver is extracted in the great works, we shall briefly describe here, after Schlutter, the smelting of the ore of Rammelsberg, which contains, as we have already said, several different kinds of metals, but particularly lead and silver.

When this mineral has been disengaged from its sulphur as much as possible, by three very long roastings, it is melted in the Lower Hartz in Saxony, in a particular kind of furnace, called a furnace for smelting upon a hollow or *casse*. *See* PLATE II. *Fig.* 13. The masonry of this furnace is composed of large, thick slates, capable of sustaining great heat, and cemented together by clay. The interior part of the furnace is three feet and a half long, and two feet broad at the back part, and one foot only the front. Its height is nine feet eight inches. It has a foundation of masonry in the ground; and in this foundation channels are made for the evaporation of the moisture. These channels are covered over with stones called *covering stones*. The hollow or casse, which is made above these, is formed of bricks, upon which are placed, first, a bed of clay; then a bed of small ore and sifted vitriols; and, lastly, a bed of charcoal-powder beat down, called *light brasque*. The anterior wall of the furnace is thinner than the others, and is called the *chemise*. The back wall, which is pierced to give passage to the pipes of two large wooden bellows, is called the middle wall. When the furnace is thus prepared, charcoal is thrown into the hollow, or casse; which being kindled, the fire is to be continued during three hours, before the matters to be fused are added. Then these matters are thrown in, which are not the

the pure ore, but a mixture of ſeveral ſubſtances, all of which are ſomewhat profitable. The quantity of theſe matters is ſufficient for one day's work; that is, for a fuſion of eighteen hours; and it conſiſts of, 1. Twelve ſchorbens or meaſures of well roaſted Rammelſberg ore; (the ſchorben is a meaſure whoſe contents are two feet five inches long, one foot ſeven inches broad, and a little more than a foot deep: It is equal to 32 quintals of that country, Cologn weight, at 123 pounds each quintal). 2. Six meaſures of ſcoria produced by the ſmelting of the ore of Upper Hartz, which is refractory, and what workmen called *cold*. 3. Two meaſures of *knobben*, which is an impure ſcoria containing ſome lead and ſilver, which has been formerly thrown away as uſeleſs, and is now collected by women and children. Beſides theſe, other matters are added, containing lead and ſilver, as the teſts employed in refining, the droſs of lead, impure litharge, and any rubbiſh containing metal, which was left in the furnace after the foregoing fuſion. All theſe matters being mixed together are thrown into the furnace: And to each meaſure of this mixture a meaſure of charcoal is added. The fuſion is then begun by help of bellows; and as it proceeds, the lead falls through the light braſque or charcoal bed, into the hollow, or caſſe, where it is preſerved from burning under the powder of charcoal. The ſcoria, on the other hand, being lighter and leſs fluid, is ſkimmed off from time to time by means of ladles, that it may not prevent the reſt of the lead from falling down into the hollow. Thus, while the fuſion laſts, freſh matters and freſh charcoal are alternately added, till the whole quantity intended for one fuſion, or, as they call it, one *day*, be thrown in.

There are ſeveral eſſential things to be remarked in this operation, which is very well contrived. Firſt, the mixture of matters from which a little lead and ſilver is procured, which would otherwiſe be loſt; and which have alſo this advantage, that they retard the fuſion of the Rammelſberg ore, which, however well roaſted it has been, retains always enough of the ſulphur and iron of the pyrites mixed with it, to render it too fuſible or too fluid, ſo that without the addition of thoſe matters, nothing would be obtained but a matt. It is even neceſſary, notwithſtanding theſe additions, not to haſten the fuſion too much, but to give time to the ore to mix with the other matters, elſe it would melt and flow of itſelf before the reſt. Secondly, the fuſion of the ore through charcoal, which is practiſed in

in moſt ſmelting-houſes, and for almoſt all ores, is an excellent method, the principal advantage of which is the ſaving of fuel. The action of the burning charcoal directed immediately upon the mineral, at the ſame time that it melts more readily and efficaciouſly, alſo ſupplies it with the phlogiſton neceſſary to bring it to a perfect ſtate.

We mentioned, when treating of vitriols obtained from the Rammelſberg ore after its firſt roaſting, that a *white vitriol* was alſo obtained, and prepared at *Goſlar*, whoſe baſis was *zinc:* which proves that this ore contains alſo a certain quantity of this ſemi-metal. As this ore is ſmelted in a country where the art is well underſtood of extracting every thing which a mineral contains, ſo in this fuſion *zinc* and *cadmia* are obtained in the following manner. When the furnace is prepared for the fuſion, it is neceſſary to cloſe it up in the fore-part, before the fuſion is begun.

" Firſt of all, a gritt-ſtone is to be placed, ſupported at " the height of three inches. This ſtone is as long as the " furnace is broad, and the height of it is level with the " hole where the bellows-pipe enters. It is faſtened on each " ſide of the furnace, externally and internally, with clay. " Upon this ſtone a kind of receptacle, or, as it is called, " the *ſeat of the zinc*, is made in the following manner. " A flat, ſlaty ſtone is choſen as long as the furnace " is broad, and eight inches in breadth. This is placed " on the gritt-ſtone above-mentioned, in ſuch a manner, " that it inclines conſiderably towards the front of the fur- " nace, and that its bottom touches cloſely the gritt-ſtone. " It is faſtened with clay, which is alſo laid upon the ſeat " of the zinc. Upon this ſeat, which is to receive the " zinc, are placed two round pieces of charcoal, and " alſo a ſtone called the *zinc-ſtone*, which is about a foot " and a half in length, and cloſes one part of the front " of the furnace. This ſtone alſo is faſtened on each " of its ſides with clay. Clay is likewiſe put under the " ſtone betwixt the two pieces of charcoal, which hinder it " from touching the ſeat of the zinc. The under part of " this ſtone is but ſlightly luted, that the workmen may " make an opening for the zinc to flow out. Thus is made " the ſeat or receptacle of the zinc to detain this metallic " ſubſtance, which would otherwiſe fall into the hotteſt " part of the fire, called by the workmen the melting-place, " and would be there burnt: whereas it is collected upon " this receptacle during the fuſion, where it is ſheltered

" from

" from the action of the bellows, and consequently from
" too great heat.

" When all the matter to be fused in one day is put into
" the furnace, the blast of air is continued till that matter
" has sunk down. When it is half way down the furnace,
" they draw out the scoria, that more of the ore and other
" matters may be exposed to the greatest heat. As soon as
" the scoria is cooled and fixed a little, two shovel-fulls of
" small wet scoria or sand is thrown close to the furnace,
" and beat down with the shovel; then the workmen open
" the seat or receptacle of zinc, and strike upon the zinc-
" stone to make the semi-metal flow out. As soon as the
" purest part of it has flowed out, it is sprinkled with
" water and carried away. Then the workmen separate
" intirely the zinc-stone from the wall of the furnace,
" and they continue to give it little strokes, that the small
" particles of zinc dispersed among the charcoal may fall
" down. This being done, the stone is removed, and the
" zinc is separated from the charcoal by an iron instru-
" ment, is cleaned, and remelted along with the zinc that
" flowed out at first, and is cast into round cakes. The
" reason why the zinc is withdrawn before the bellows
" cease to blow, is, that if it was left till the charcoal on
" the seat or receptacle was consumed, it would be mostly
" burnt, and little would be obtained. Thus, after the
" zinc is withdrawn, the fusion is finished by blowing the
" bellows till the end."

Thus the zinc is separated from the ore of Rammelsberg, and is not confounded in the hollow or casse with the lead and silver, because being a volatile semi-metal, it cannot support the activity of the fire without rising into vapors, which are condensed in the place least hot, that is to say, upon the stones expressly prepared for that purpose, and which being much thinner than the other walls of the furnace, are continually cooled by the external air.

It is also in this furnace, and after the fusion of the Rammelsberg ore, that the *cadmia of zinc*, or the *cadmia of furnaces*, is obtained. This ore is composed of sulphureous and ferruginous pyrites, of true lead ore containing silver, and a very hard and compact matter of a dark brownish-grey color, which is probably a lapis calaminaris, or an ore of zinc. These several matters of the Rammelsberg ore are not separated from each other, either for the roasting or for the fusion. Thus there is zinc in all the parts of the roasted ore, and much more of it would be obtained,

if

if it was not so easily inflammable. All the zinc which is obtained is preserved from burning by falling, while in fusion, behind the chemise or forepart of the furnace, which is, as has been said, a kind of schistus, or slate, called by the workmen *steel stone*. But the part of this semi-metal which falls in the middle of the furnace, near the middle wall, or towards the sides, being exposed to the greatest heat of the fire, is there burnt; and its smoke or flowers attaching itself on all sides to the walls of the furnace, undergo there a semi-fusion, which renders this matter so hard and so thick that it must be taken away after every fourth fusion, or, at most, after every sixth fusion. That which is found attached to the highest part of the furnace is the best and purest. The rest is altered by a mixture of a portion of lead which it has carried up with it, and which, from its great weight and fixity, has hindered the zinc from rising so high as it would have done alone. Therefore with this kind of impure cadmia ductile brass cannot be made.

Almost all the zinc we have, as well as the cadmia of the furnaces, is obtained from the Rammelsberg ore, by the process described, and consequently is not the produce of a pure ore of zinc, or lapis calaminaris, which is never fused for that purpose. Before Mr. Margraaf, although it was well known that this ore contained zinc, and that it was employed for the making of brass, a convenient process for extracting zinc from it was not known, because when treated by fusion with fluxes, like other ores, it does not yield any zinc; which proceeds partly from the refractory quality of the earth contained in the calamine, that cannot be fused without a very violent fire; and also from the volatility and combustibility of the zinc, which for this reason cannot be collected at the bottom of a crucible, as a regulus under a scoria, like most metals.

M. Margraaf has remedied these inconveniences by distilling lapis calaminaris, mixed with charcoal, in a retort, to which is joined a receiver containing some water, and consequently in close vessels, where the zinc, by the help of a very strong fire indeed, is sublimed in its metallic form without burning. He also by the same method reduced into zinc the *flowers of zinc*, or *pompholix*, *cadmia of the furnaces*, *tutty*, which is also a kind of cadmia; in a word, all matters capable of producing zinc by combination with phlogiston. But it is evident that such operations as these are rather fit to supply proofs for chemical theory, than to be put in practice

practice for works in great. *(n)* M. Margraaf has obſerved, that the zinc which he obtained by this proceſs was leſs brittle than what is obtained from the fuſion of ores; which may proceed from its greater purity, or from its better combination with phlogiſton.

After this digreſſion which we have now made concerning the operation in the great, by which zinc and cadmia are obtained, and which we could not inſert elſewhere, becauſe of the neceſſary relation it has with the ſmelting of the Rammelſberg ore, we proceed to the other operations of the ſame ore, that is to ſay, to the *finery*, by which the ſilver is ſeparated from the lead, which are mixed together, forming what is called the *work*.

This operation differs from the fining of eſſay, or in ſmall, principally in this circumſtance, that in the latter method of fining, all the litharge is abſorbed into the cupel, whereas in the former method the greateſt part of this litharge is withdrawn.

The fining in great of the work of Rammelſberg is performed in a furnace called a *reverberatory furnace*. This furnace is ſo conſtructed that the flame of wood burning in a cavity called the fire-place, is determined by a current of air, (which is introduced through the aſh-hole, and which goes out at an opening on one ſide of that part of the furnace where the work is, that is, where the lead and ſilver are) to circulate above, and to give the convenient degree of heat, when the fire is properly managed. In this furnace a great cupel, called a *teſt*, is diſpoſed. This teſt is made of the aſhes of beech-wood, well lixiviated in the uſual manner. In ſome founderies different matters are added, as ſand, ſpar, calcined gypſum, quicklime, clay. When the teſt is well prepared and dried, all the work is put at once upon the cold teſt, to the quantity of ſixty-four quintals for one operation. Then the fire is lighted in the fire-place with

*(n)* ZINC is obtained not only in the method uſed at Goſlar above-deſcribed, but is alſo extracted in great works from lapis calaminaris and calcined blend, by a diſtillation ſimilar to that by which Mr. Margraaf has eſſayed ores of zinc. The firſt work of that kind was erected in Sweden by Mr. Von Swab, in the year 1738. The ore employed was a kind of blend; this ore, when calcined, powdered, and mixed with charcoal, was put into iron or ſtone retorts, and the zinc was obtained by diſtillation. In Briſtol a work is eſtabliſhed in which zinc is obtained by diſtillation *by deſcent*. See a ſection and deſcription of the furnace and apparatus employed, PLATE II. *Fig.* 22, and *explanation*.

faggots, but the fusion is not urged too fast; 1. That the test may have time to dry; 2. Because the work of the Rammelsberg ore is allayed with the mixture of several metallic matters, which it is proper to separate from it, otherwise they would spoil the litharge and the lead procured from it. These metallic matters are, copper, iron, zinc, and matt. As these heterogeneous substances are hard and refractory, they do not melt so soon as the *work*, that is, as the lead and silver; and when the work is melted, they swim upon its surface like a skin, which is to be taken off. These impurities are called the *scum*, or the *first-waste*. What remains forms a second scum, which appears when the work is at its greatest degree of heat, but before the litharge begins to form itself. It is a scoria which is to be carefully taken off, and is called the *second-waste*.

When the operation is at this point, it is continued by the help of bellows, the wind of which is directed, not upon the wood or fuel, but upon the very surface of the metal, by means of iron plates put for that purpose before the blast hole, which are called *papillons*. This blast does not so much encrease the intensity of the fire, as it facilitates the combustion of the lead, and throws the litharge that is not imbibed by the test towards a channel, called the *litharge way*, through which it flows. The litharge becomes fixed out of the furnace; the matter which is found in the middle of the largest pieces, and which amounts to about a half or a third of the whole, is friable, and falls into powder like sand. This is put into barrels containing each five quintals of it, and is called saleable litharge, because it is sold in that state. The other part which remains solid is called *cold litharge*, and is again melted and reduced into lead. The fusion is called *cold fusion*, and the lead obtained from it, *cold lead*, which is good and saleable when the *work* has been well cleared from the heterogeneous matters mentioned above. The tests and cupels impregnated with litharge are added in the fusion of the ore, as we have already related.

When two-thirds, or nearly that quantity, of the lead are converted into litharge, no more of it is formed. The silver then appears covered with a white skin, which the finers call *lightening*, and the metal, *lightened* or *fined silver*.

The silver obtained by this process of fining is not yet altogether pure. It still contains some lead, frequently to the quantity of four drams in each marc, or eight ounces. It is delivered to the workmen, who complete its purification

purification by the ordinary method. This laſt operation is the *refining*, and the workmen employed to do it are called *refiners*. A fining of ſixty-four quintals of *work*, yields from eight to ten marcs of fined ſilver, and from thirty-five to forty quintals of litharge; that is, from twelve to eighteen of ſaleable litharge, from twenty-two to twenty-three of cold litharge, from twenty to twenty-two quintals of impregnated teſt, and from ſix to ſeven quintals of lead-droſs. The operation laſts from ſixteen to eighteen hours. *(o)*

SMELT-

*(o)* Ores containing ſilver may be divided into four kinds. 1. *Pure*, or thoſe which are not much compounded with other metals. 2. *Galenical*, in which the ſilver is mixed with much *galena* or ore of lead mineraliſed by ſulphur. 3. *Pyritous*, in which the ſilver is mixed with the martial pyrites. 4. *Cupreous*; in which the ſilver is contained in copper-ores. To extract the ſilver from theſe ſeveral kinds of ores, different operations are neceſſary.

*Native ſilver* is ſeparated from its adhering earths and ſtones by amalgamation with mercury, in the manner directed for the ſeparation of gold; or by fuſion with lead, from which it may be afterwards ſeparated by cupellation.

*Pure ores* ſeldom require a previous calcination; but, when bruiſed and cleanſed from extraneous matters, may be fuſed directly, and incorporated with a quantity of lead, unleſs they contain a large proportion of ſulphur and arſenic; in which caſe a calcination may be uſeful. The lead employed muſt be in a calcined or vitrified ſtate, which, being mixed with the ore, and gradually reduced by the phlogiſton of the charcoal added to it, may be more effectually united with the ſilver of the ore, than if lead itſelf had been added, which would too quickly precipitate to the bottom of the containing veſſel or furnace. The ſilver is to be afterwards ſeparated from the lead by cupellation.

*Galenical ores*, eſpecially thoſe in which pyrites is intermixed, require a calcination, which ought to be performed in an oven, or reverberatory furnace. They are then to be fuſed together with ſome inflammable matter, as charcoal, by which the lead is revived, and, together with the ſilver, is precipitated.

*Pyritous ores* muſt be firſt melted, ſo as to form a matt. If the ſulphur is not ſufficient for this kind of fuſion, more ſulphurated pyrites may be added. This matt contains, beſides ſilver and ſulphur, alſo various metals, as lead, iron, and ſometimes cobalt. The matt muſt be expoſed to repeated calcinations till the ſulphur is diſſipated. By theſe calcinations moſt of the iron is deſtroyed. The calcined matt is to be fuſed with litharge, and the ſilver incorporated with the revived lead; from which, and

 from

## SMELTING *of* ORES *of* COPPER.

The ſmelting in great of copper ores, and even of ſeveral ores of ſilver and lead, excepting that of Rammelſberg, is performed in furnaces not eſſentially different from that already deſcribed; but in this reſpect only, that the ſcoria

from the other imperfect metals with which it may be mixed, it muſt afterwards be ſeparated by cupellation. *See* REFINING.

The ſilver contained in *cupreous ores* may be obtained, either, 1. By ſeparating it from the copper itſelf, after this has been extracted along with the ſilver, in the uſual manner, from the ore; or, 2. By precipitating it immediately from the other matters of the ore.

1. It may be ſeparated from the copper by two methods. One of theſe is by adding lead, and ſcorifying the imperfect metals. By this method much of the copper would be deſtroyed, and it is therefore not to be uſed unleſs the quantity of ſilver relatively to the copper be conſiderable. Another method by which ſilver may be ſeparated from copper is, by *eliquation*; that is, by mixing the maſs of copper and ſilver with a quantity of lead, and applying ſuch a heat as ſhall be juſt ſufficient to make the lead eliquate from the copper, together with the ſilver, which being more ſtrongly diſpoſed to unite with the lead than with the copper, is thus incorporated with the former metal, and ſeparated from the latter. *See the article* ELIQUATION.

2. Silver may alſo be extracted from theſe cupreous ores by *precipitation*. For this purpoſe let the ore, previouſly bruiſed and cleanſed, be formed into a matt, that the earthy matters may be well ſeparated. Let the matt be then fuſed with a ſtrong heat; and when the ſcoria has been removed, and the heat is diminiſhed, add to it ſome clean galena, litharge, and granulated lead. When the fire has been raiſed, and the additions well incorporated with the matt, let ſome caſt or filed iron be thrown into the liquid maſs, which being more diſpoſed than lead is to unite with ſulphur, will ſeparate and precipitate the latter metal, and along with it the ſilver or gold contained in the matt. This method was introduced by Scheffer, and is practiſed at Adelſors in Smoland. In this work the proportion of the ſeveral materials is, four quintals of matt, two quintals of black copper containing ſome lead with the perfect metal, one quintal of galena, one quintal of litharge, a fifth part of a quintal of granulated lead, and an equal quantity of caſt iron.

The ſilver in this, and in all other inſtances where it is united with lead, is to be afterwards ſeparated from the lead by cupellation; which proceſs is deſcribed at the articles ESSAY *of the* VALUE *of* SILVER, *and* REFINING.

and

and metal are not drawn out of the furnace, but flow ſpontaneouſly, as ſoon as they are melted, into *receiving baſons*, where the metal is freed from the ſcoria. Theſe furnaces are generally called *pierced furnaces*.

Inſtead of a light braſque, or bed of charcoal-powder, under which the metal lies hid, the bottom of theſe furnaces is covered with a baſon compoſed of heavy braſque, which is a mixture of charcoal-powder and clay. In the front of the furnace, and at the bottom of the chemiſe, there is a hole, called the *eye*, through which the melted matter flows, and runs along a trench or furrow, called the *trace*, into one or more *receiving baſons*, made of earth, ſcoria, ſand, &c. There the metal is ſeparated from the ſcoria, by making it flow from theſe baſons into another lateral one. Theſe furnaces are alſo called *crooked furnaces*.

Different names are given to them according to ſome difference in their conſtruction. For inſtance, thoſe which have two *eyes*, and two *traces*, through which the melted matter flows alternately into two baſons, are called *ſpectacle-furnaces*. Their greater or leſs height gives occaſion alſo to the diſtinction of *high furnaces*, and *middle furnaces*.

The high furnaces are of modern invention. They were firſt introduced at Mansfeldt in the year 1727, and they are now uſed in almoſt all countries where ores are ſmelted, as in Saxony, Bohemia, Hungary, &c. Their chief advantage conſiſts in ſimplifying and diminiſhing the labor. This advantage is effected by the great height of the furnace, which allows the ore to remain there a long time before it falls down into the hotteſt part of the fire, and is melted. Conſequently, it ſuffers ſucceſſively different degrees of heat, and, before it is melted, it undergoes a roaſting which coſts nothing; therefore the high furnaces are chiefly employed for crude fuſions; and particularly for the ſlate copper-ore. Theſe furnaces are above eighteen feet high. A too great height is attended with an inconvenience, beſides the trouble of ſupplying it with ore and fuel, which is, that the charcoal is moſtly conſumed before it gets down where the greateſt heat is required, and is then rendered incapable of maintaining a fire ſufficiently intenſe.

All the furnaces which we have mentioned are ſupplied with large bellows, moved by the arbor of a wheel, which is turned round by a current of water.

The only kind of furnace for ſmelting ores where bellows are not employed, is what is called a *reverberatory*

*furnace.* The Germans call it a *wind-furnace.* It is alſo diſtinguiſhed by the name of *Engliſh furnace*, becauſe the invention of it is attributed to an Engliſh phyſician of the name of *Wright*, who was well verſed in chemiſtry; and becauſe the uſe of it was firſt introduced in England about the end of the laſt century, where it is much employed, as well as in ſeveral other countries, as at Konigſberg, in Norway. *See* PLATE II. *Fig.* 14. *and* 15.

The length of theſe furnaces is about eighteen feet, comprehending the maſonry: their breadth is twelve feet, and their height nine feet and a half. The hearth is raiſed three feet above the level of the foundery: on one ſide is the fire-place, under which is an aſh-hole hollowed in the earth; on the other ſide is a baſon made, which is kept covered with fire when there is occaſion: on the anterior ſide of this furnace there is a chimney, which receives the flame after it has paſſed over the mineral that is laid upon the hearth. This hearth, which is in the interior part of the furnace, is made of clay capable of ſuſtaining the fire. The advantage of this furnace is, that bellows are not neceſſary, and conſequently it may be conſtructed where there is no current of water, and wherever the mine happens to be. This furnace has a hole in its front through which the ſcoria is drawn out; and a baſon, as we have ſaid, on one ſide, made with ſand, in which are oblong traces for the reception of the *matt*, and of the *black copper*, when they flow out of the furnace.

Copper is generally mineraliſed, not only by ſulphur and arſenic, but alſo by ſemi-metals and pyritous matters, and is frequently mixed with other metals. As this metal has great affinity with ſulphur and arſenic, it is almoſt impoſſible to diſengage it from them entirely by roaſting: hence in the ſmelting in great, nothing is obtained by the firſt operation but a copper-matt, which contains all the principles of the ore, excepting the earthy and ſtony parts, particularly when the ore is ſmelted, crude, and unroaſted. Afterwards this matt muſt be again roaſted and fuſed. The produce of this ſecond fuſion begins ſtill more to reſemble copper, but is not malleable. It continues mixed with almoſt all the minerals, particularly with the metals. As it is frequently of a black color, it is always called *black copper*, when it is unmalleable, whatever its color happens really to be.

As, of all the imperfect metals, copper is moſt difficultly burnt and ſcorified, it is again remelted ſeveral times, in order

order to burn and ſcorify the metallic ſubſtances mixed with it; and this is done till the copper is perfectly pure, which is then called *red*, or *refined copper*, and theſe laſt fuſions are called the fining and refining of it: Red copper contains no metals but gold and ſilver, if any of theſe happened to be in the ore.

In order to avoid all theſe fuſions, it has been propoſed to treat in the humid way certain copper ores, particularly thoſe which are very pyritous. This method conſiſts in making blue vitriol from the ore, by roaſting and lixiviating it, and in precipitating pure copper from this lixivium, which is called *cement-water*, by means of iron: but it is not much practiſed, becauſe it has been obſerved, that all the copper contained in the ore was not procured by this means.

As expence is not much regarded in ſmall eſſays and experiments, theſe fuſions are much abridged and facilitated by adding at firſt ſaline and glaſſy fluxes; and then by refining the black copper with lead in the cupel, as gold and ſilver are done. In this method of refining, it is to be moſt carefully obſerved, that the metal be fuſed as quickly as poſſible, and expoſed to no more heat than is neceſſary, leſt it be calcined.

When the black copper contains ſome iron, but not a great deal, the lead preſently ſeparates the iron from it, and makes it riſe to the ſurface of the copper: but if the iron be in too large a proportion, it prevents the lead from uniting with the copper. Theſe two phenomena depend on the ſame cauſe, which is, that lead and iron cannot unite.

Frequently copper ores contain alſo a quantity of ſilver ſufficient to make its extraction by particular proceſſes profitable. It was long before any proceſs could be thought of for this purpoſe which was not too expenſive and troubleſome; but at length it is accompliſhed by the excellent operation called *eliquation*. *See the word* ELIQUATION.

The copper from which ſilver has been ſeparated by eliquation muſt be refined after this operation, as it is generally black copper from which ſilver is extracted; but even if it had not been black copper which was employed for this operation, it would require to be refined on account of a little lead it always retains. It is therefore carried to the refiners furnace, where this operation is performed by help of bellows, the blaſt of which is thrown upon the ſurface of the melted metal. As in this refining of copper

the precise time when it becomes pure cannot be known, because scoria is always formed on its surface, it is necessary to use an *essay-iron*, the polished end of which being dipt in melted copper, shews that this metal is pure when the copper adhering to the iron falls off as soon as it is dipt in cold water.

When this mark of the purity of the copper has been observed, its surface ought to be well cleaned; and as soon as it begins to fix, it must be sprinkled with a broom or besom dipt in cold water. The surface of the copper which is then fixing, being suddenly cooled by the water, detaches itself from the rest of the metal, is taken hold of by tongs, and is thrown red-hot into cold water. By again sprinkling water on the mass of copper, it is all of it reduced into plates, which are called *rosettes*, and these plates are what is called *rosette-copper*. *(p)*

We

*(p)* The copper of pyritous cupreous ores cannot be obtained without several operations, which vary according to the nature of the ores. These operations are chiefly roastings and fusions. By the first fusion a matt is produced, which is afterwards to be roasted; and thus the fusions and roastings are to be alternately applied, till by the last fusion copper is obtained. These methods of treating pyritous copper ores depend on the two following facts: 1. Sulphur is more disposed to unite with iron than with copper. 2. The iron of these ores is destructible by the burning sulphur during the roasting or the fusion of the ores, while the copper is not injured. This fact appears from experiments mentioned by Scheffer and by Wallerius, and from the daily practice of smelting cupreous ores.

From these facts we learn, 1. That sulphur may be employed to separate and destroy iron mixed with copper; 2dly, that iron may be employed to separate the sulphur from copper, as is sometimes done in the essay of sulphurated copper-ores; and, 3dly, that by adjusting the proportion of the iron and sulphur to each other in the smelting of copper-ores, these two substances may be made to destroy each other, and to procure a separation of the copper; and this adjustment may be effected, by adding sulphur or sulphureous pyrites to the copper-ore, when the quantity of sulphur contained in this ore relatively to the iron is too small; or by adding iron when the sulphur predominates; or by roasting, by which the superfluous sulphur may be expelled, and no more left than is sufficient for the destruction of the iron contained in the ore. We shall apply these principles to the following cases.

1. When

We ſhall not enter into further details concerning the operations made in great upon the different minerals, that we may not exceed the bounds intended for this work. Beſides, what remains to be ſaid upon the ores of mercury, antimony, biſmuth, arſenic, and cobalt, is already ſufficiently explained in the different articles of this Dictionary relating to theſe ſubſtances, and to their products. The fuſion in great of ores of iron would indeed particularly deſerve to be treated more extenſively, on account of its importance; but we obſerve, that the general principles

1. When the quantity of ſulphur and of iron in a copper-ore is ſmall, and eſpecially when the iron does not too much abound, a previous roaſting will at once calcine the iron, and expel moſt of the ſulphur; ſo that by one fuſion the calcined iron may be ſcorified, and black copper may be obtained. If the ſulphur has not been ſufficiently expelled, a ſecond roaſting and fuſion are requiſite; for the whole quantity of ſulphur ought not to be expelled during the firſt roaſting; but as much ought to be left as is ſufficient for the ſcorification of the calcined iron, otherwiſe this might, during the fuſion, be again revived and united with the copper.

2. If, in a copper-ore, the quantity of iron be too great, relatively to the ſulphur, ſome ſulphurated pyrites, eſpecially that kind which contains copper, ought to be added, that a matt may be obtained, and that the iron may be calcined and ſcorified.

3. When the quantity of ſulphur and iron is very great, that is, when the ore is very pyritous and poor, it ought to be firſt formed into a matt; by which it is ſeparated from the adherent earths and ſtones, and the bulk is diminiſhed: then by repeated and alternate roaſtings and fuſions, the copper may be obtained.

4. When the quantity of ſulphur in an ore is greater than is ſufficient for the forming a matt, the ſuperfluous quantity ought to be previouſly expelled by roaſting.

The copper thus at firſt obtained is never pure, but is generally mixed with ſulphur or with iron. It is called *black copper*. This may be refined in furnaces, or on hearths.

In the former method, to the copper when melted a ſmall quantity of lead is added, which unites with the ſulphur, and is ſcorified together with the iron, and floats upon the ſurface of the melted copper. This purification of copper by means of lead is ſimilar to the refining of ſilver by cupellation, and is founded on the property of lead, by which it is more diſpoſed to unite with ſulphur than copper is, and on a property of copper, by which it is leſs liable than any other imperfect metal to be ſcorified by lead. But as copper is alſo capable of being ſcorified by lead,

ples of the ſmelting of ores contained in the preſent article are as applicable to ores of iron as of other metals, and for the particular details we are obliged to refer to good Treatiſes, which are not wanting on this ſubject, and particularly to the *Art of Forges and Iron-furnaces*, deſcribed moſt exactly by the Marquis de Courtivron, of the Royal Academy of Sciences, and by M. Bouchu, a correſpondent of that Academy; a work which makes part of a general deſcription of the Arts undertaken by that illuſtrious company. *(q)*

SNOW

lead, this operation muſt be no longer continued, and no more lead muſt be employed than is ſufficient for the ſeparation of the ſulphur, and for the ſcorification of the iron.

The copper might alſo be purified from any remaining ſulphur by adding a ſufficient quantity of iron to engage the ſulphur. Thus Mr. Scheffer found, that by adding to ſulphurated copper from $\frac{1}{20}$th to $\frac{1}{40}$th of old caſt iron, he rendered the copper pure and ductile. *See his Diſſertation on the Parting of Metals amongſt the Swediſh Memoirs for the year* 1752. In this purification, the quantity of iron added ought not to be too little, elſe all the ſulphur will not be ſeparated; and it ought not to be too great, elſe the ſuperfluous quantity will unite with and injure the purity of the copper. The fuſion and ſcorification, with addition of lead, ſeems to be the beſt method for the laſt purification of copper.

*(q)* In this work, which pretends to treat of the chemical principles of arts in general, we ought certainly not to omit ſome deſcription of the methods of procuring and manufacturing a metal, ſo extenſively uſeful, that without it no other art could have been perfected, and even, as ſome writers have obſerved, mankind could ſcarcely have been civilized.

In the article IRON, the author of the Dictionary has deſcribed the chemical properties of that metal, or its effects when acted upon by fire, acids, and other ſubſtances. The ſubjects of this note and of the article STEEL are the proceſſes by which iron is obtained from its ores, and reduced to the ſeveral ſtates of *caſt iron*, *forged iron*, and *ſteel*, and the properties of this metal in theſe ſeveral ſtates, which render it fit for the various uſes to which it is daily applied.

Notwithſtanding the great importance of theſe ſubjects, and the labors of Reaumur, Swedenborgius, and of ſome other authors, we have ſtill a very imperfect knowledge of the cauſes of the differences of the ſeveral kinds of ores, of the methods of ſmelting beſt adapted to theſe differences, of the cauſes of the good and bad qualities of different kinds of iron, and of the means

SNOW *of* ANTIMONY. The flowers of regulus of antimony are so called. *See* FLOWERS *of* REGULUS *of* ANTIMONY.



means of so meliorating this metal, that we may obtain tough and ductile iron from any of its ores.

Swedenborgius has very industriously and exactly described the different processes now used in most parts of Europe for the smelting of ores of iron, for the forging of that metal, and for the conversion of it into steel: but we do not find that he or any other author have, by experiments and discoveries, contributed much to the illustration or to the improvement of this part of metallurgy, unless, perhaps, we except those of Mr. Reaumur, concerning the softening of cast iron by cementation with earthy substances.

The *ores of iron* are known to vary much in their appearance, in their contents, in their degrees of fusibility, in the methods necessary for the extraction of their contained metal, and in the qualities of the metal when extracted.

Most ores require to be *roasted* previously to their fusion; some more slightly, and others with a more violent and longer-continued fire. Those which contain much sulphur, arsenic, or vitriolic acid, require a long-continued and repeated roasting, that the volatile matters may be expelled. Of this kind is the *black-iron ore*, from which the Swedish iron is said to be obtained.

Some ores require a very slight roasting only, that they may be dried and rendered friable. Such are the ores called *bog ores*, and others which being in a calcined state, and containing little sulphureous matter, would, by a further calcination, be rendered less capable of being reduced to a metallic state.

The roasting of ores of iron is performed by kindling piles, consisting of strata of fuel and of ore placed alternately upon one another, (*See* PLATE II. *Fig.* 11. *and* 12.) or in furnaces similar to those commonly employed for the calcination of limestone.

Some authors advise the addition of a calcareous earth to sulphureous ores during the roasting, that the sulphur may be absorbed by this earth when converted into quicklime. But we may observe, that the quicklime cannot absorb the sulphur or sulphureous acid, till these be first extricated from the ore, and does therefore only prevent the dissipation of these volatile matters; and, secondly, that the sulphur thus united with the quicklime forms a hepar of sulphur, which will unite with and dissolve the ore during its fusion, and prevent the precipitation of the metal.

The next operation is the *fusion* or *smelting* of the ore. This is generally performed in furnaces or towers, from twenty to thirty

SOAP. The name *ſoap* was formerly employed only to ſignify combinations of alkaline ſalts with oils, that is, compounds

thirty feet high, in the bottom of which is a baſon for the reception of the fluid metal. *See a Section and Deſcription of this Furnace in* PLATE II. *Fig.* 20. *and the Explanation of that Figure.* When the furnace is ſufficiently heated, which muſt be done at firſt very gradually, to prevent the cracking of the walls; a quantity of the ore is to be thrown in, from time to time, at the top of the furnace, along with a certain quantity of fuel and of limeſtone, or whatever other flux is employed. While the fuel below is conſumed by the fire excited by the wind of the bellows, the ore, together with its proportionable quantity of fuel and of flux, ſink gradually down, till they are expoſed to the greateſt heat in the furnace. There the ore and the flux are fuſed, the metallic particles are revived by the fuel, are precipitated by means of their weight through the ſcoria formed of the lighter earthy parts of the flux and of the ore, and unite in the baſon at the bottom of the furnace, forming a maſs of fluid metal covered by a glaſſy ſcoria. When a ſufficient quantity of this fluid metal is collected, which is generally twice or thrice in twenty-four hours, an aperture is made, through which the metal flows into a channel or groove made in a bed of ſand; and from thence into ſmaller lateral or connected channels, or other moulds. There it is cooled, becomes ſolid, and retains the forms of the channels or moulds into which it flows. The piece of iron formed in the large channel is called *a ſow*, and thoſe formed in the ſmaller channels are called *pigs*. Sometimes the fluid iron is taken out of the furnace by means of ladles, and poured into moulds, ready prepared, of ſand or of clay, and is thus formed into the various utenſils and inſtruments for which caſt iron is a proper material.

The *ſcoria* muſt be, from time to time, allowed to flow out, when a conſiderable quantity of it is formed, through an aperture made in the front of the furnace for that purpoſe. A ſufficient quantity of it muſt, however, be always left to cover the ſurface of the melted iron, elſe the ore which would fall upon it, before the ſeparation of its metallic from its unmetallic parts, would leſſen the fluidity and injure the purity of the melted metal. This ſcoria ought to have a certain degree of fluidity; for if it be too thick, the revived metallic particles will not be able to overcome its tenacity, and collect together into drops, nor be precipitated. Accordingly, a ſcoria, not ſufficiently fluid, is always found to contain much metal. If the ſcoria be too thin, the metallic particles of the ore will be precipitated before they are ſufficiently metallized, and ſeparated from the earthy and unmetallic parts. A due degree of fluidity is given to the ſcoria by

compounds in which oils are rendered miſcible with water, by means of an alkali. But ſince chemiſts, by a more exact

by applying a proper heat, and by adding fluxes ſuited to the ore.

Some ores are fuſible without addition, and others cannot be ſmelted without the addition of ſubſtances capable of facilitating their fuſion.

The *fuſible ores* are thoſe which contain ſulphur, arſenic, or are mixed with ſome fuſible earth.

The *ores difficultly fuſible* are, thoſe which contain no mixture of other ſubſtance. Such are moſt of the ores which contain iron in a ſtate nearly metallic. As iron itſelf, when purified from all heterogeneous matters, is ſcarcely fuſible without addition, ſo the metal contained in theſe purer kinds of ores cannot be eaſily extracted without the addition of ſome fuſible ſubſtance. 2. Thoſe which are mixed with ſome very refractory ſubſtance. Some of theſe refractory ores contain arſenic; but as this ſubſtance facilitates the fuſion of iron, we may preſume that their refractory quality depends upon a mixture of ſome unmetallic earth or other unfuſible ſubſtance. The earth which is mixed with the common calciform ores is in conſiderable quantity, and is ſometimes calcareous, ſometimes ſiliceous, and ſometimes argillaceous.

Perhaps the fuſibility of ſome ores depends greatly on the degree of calcination to which the metal contained in them has been reduced; ſince we have reaſon to believe that, by a very perfect calcination, ſome metals, at leaſt, may be reduced to the ſtate of an earth almoſt unfuſible, and incapable of metalliſation (*ſee the article* METALS); and ſince we know, that in every calcination and ſubſequent reduction of a given quantity of any imperfect metal, a ſenſible part of that quantity is always loſt or deſtroyed, however carefully theſe operations may have been performed. That ſome of theſe ores are already too much calcined, appears from the inſtance above-mentioned of the *bog ores*, which are injured by roaſting; and even the great height of the common ſmelting furnaces, although advantageous to many ores that require much roaſting, is ſaid to be injurious to thoſe which are already too much calcined, by expoſing them to a further calcination, during their very gradual deſcent, before they arrive at the hotteſt part of the furnace, where they are fuſed.

But, as too violent calcination renders ſome ores difficultly fuſible; ſo too ſlight calcination of other ores injures the purity of the metal, by leaving much of the ſulphureous or other volatile matter, which ought to have been expelled.

Various *ſubſtances are added to aſſiſt the fuſion of ores* difficultly fuſible. Theſe are: 1. *Ores* of a fuſible quality, or which, being mixed

exact examination of the nature of bodies, have discovered, that acids, and even other saline substances, may also be united

mixed with others of a very different quality, become fusible: accordingly, in the great works for smelting ores of iron, two or more different kinds of ore are commonly mixed, to facilitate the fusion, and also to meliorate the quality of the iron. Thus an ore yielding an iron which is brittle when hot, which quality is called *red-short*, and another ore which produces iron brittle when cold, or *cold-short*, are often mixed together; not, as is sometimes supposed, that these qualities are mutually destructive of each other, but that each of them is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality. Thus, if from two such ores the mass of iron obtained consists of equal parts of cold-short and of red-short iron, it will have both these qualities, but will be only half as *cold-short* as iron obtained solely from one of the ores, and half as *red-short* as iron obtained only from the other ore. 2. *Earths* and *stones* are also generally added to facilitate the fusion of iron ores. These are such as are fusible, or become fusible when mixed with the ore, or with the earth adhering to it. Authors direct that, if this earth be of an argillaceous or siliceous nature, limestone or some calcareous earth should be added; and that if the adherent earth be calcareous, an argillaceous or siliceous earth should be added; because these two earths, though singly unfusible, yet, when mixed, mutually promote the fusion of each other: but as limestone is almost always added in the smelting of iron ores, and as in some of these, at least, no argillaceous or siliceous earth appears to be contained, I am inclined to believe, that it generally facilitates the fusion, not merely by uniting with those earths, but by uniting with that part of the ore which is most perfectly calcined, and least disposed to metallisation; since we know, that by mixing a calciform or roasted ore of iron with calcareous earth, without any inflammable matter, these two substances may be totally vitrified. *See Experiments made upon Quicklime, and upon Iron, by Mr. Brandt, in the Swedish Memoirs for the years* 1749 *and* 1751. Calcareous earth does indeed so powerfully facilitate the fusion of iron ores, that it deserves to be considered whether workmen do not generally use too great a quantity of it, in order to hasten the operation. For when the scoria is rendered too thin, much earthy or unmetallized matter is precipitated, and the cast-iron produced is of too vitreous a quality, and not sufficiently approximated to a true metallic state.

Some authors pretend, that a principal use of the addition of lime-stone in the smelting of iron-ores is to absorb the sulphur, or vitriolic acid, of these ores: but, as we have already observed, a hepar

united with oils, and may render these miscible with water, they have generalised the name of soap, and the best chemists give

a hepar of sulphur is formed by that mixture of calcareous earth and sulphur, which is capable of dissolving iron in a metallic state; and thus the quantity of metal obtained from an ore not sufficiently divested of its sulphur, or vitriolic acid, (which, by uniting with the fuel, is formed into a sulphur during the smelting) must be considerably diminished, though rendered purer by addition of calcareous earth: hence the utility appears of previously expelling the sulphur and vitriolic acid from the ore by a sufficient roasting. 3. The *scoria* of former smeltings is frequently added to assist the fusion of the ore; and, when the scoria contains much iron, as sometimes happens in ill-conducted operations, it also encreases the quantity of metal obtained.

The quantity of these fusible matters to be added varies according to the nature of the ore; but ought in general to be such, that the scoria shall have its requisite degree of thinness, as is mentioned above.

The *fuel* used in most parts of Europe for the smelting of ores of iron is charcoal. Lately, in several works in England and Scotland, iron-ore has been smelted by means of pitcoal, previously reduced to cinders or *coaks*, by a kind of calcination similar to the operation for converting wood into charcoal, by which the aqueous and sulphureous parts of the coal are expelled, while only the more fixed bituminous parts are left behind. In France pitcoal not calcined has been tried for this purpose, but unsuccessfully. The use of *peat* has also been introduced in some parts of England.

The quality of the iron depends considerably upon the quality and also upon the quantity of the fuel employed. Charcoal is fitter than coaks for producing an iron capable of being rendered malleable by forging.

The quantity of fuel, or the intensity of the heat, must be suited to the greater or less fusibility of the ore. Sulphureous and other ores easily fusible, require less fuel than ores difficultly fusible. In general, if the *quantity of fuel be too small*, and the heat not sufficiently intense, all the iron will not be reduced, and much of it will remain in the scoria, which will not be sufficiently thin. This defect of fuel may be known by the blackness and compactness of the scoria, by the qualities of the iron obtained, which in this case is hard, white, light, intermixed with scoria, smooth in its texture, without scales or grains, rough and convex in its surface, and liable to great loss of weight by being forged: and, lastly, it may be known by observing the color and appearance of the drops of metal falling down from the smelted ore, and of the scoria upon the surface of the fluid metal, both which

give it now to all combinations of any ſaline ſubſtances with oils, rendered miſcible with water by means of theſe ſaline ſubſtances

which are darker colored than when more fuel is uſed. When the *quantity of fuel is ſufficiently large*, and the heat is intenſe enough, the iron is darker-colored, denſer, more tenacious, contains leſs ſcoria, and is therefore leſs fuſible, and loſes leſs of its weight by being forged. Its ſurface is alſo ſmoother and ſomewhat concave; and its texture is generally granulated. The ſcoria, in this caſe, is of a lighter color and leſs denſe. The drops falling from the ſmelted ore, and the liquid ſcoria in the furnace, appear hotter and of a brighter color. When the quantity of fuel is too great, and the heat too intenſe, the iron will appear to have a ſtill darker color, and more conſpicuous grains or plates, and the ſcoria will be lighter, whiter, and more ſpungy. The drops falling from the ſmelted ore, and the fluid ſcoria, will appear to a perſon looking into the furnace through the blaſt-hole to be very white and ſhining hot. The quantity of charcoal neceſſary to produce five hundred weight of iron, when the ore is rich, the furnace well contrived, and the operation ſkilfully conducted, is computed to be about forty cubic feet; but is much more in contrary circumſtances.

The *time, during which the fluid metal ought to be kept in fuſion* before it is allowed to flow out of the furnace, muſt be alſo attended to. How long that time is, and whether it ought not to vary according to the qualities of ores and other circumſtances, I cannot determine. In ſome works the metal is allowed to flow out of the furnace every ſix or eight, and in others only every ten or twelve hours. Some workmen imagine, that a conſiderable time is neceſſary for the concoction of the metal. This is certain, that the iron undergoes ſome change by being kept in a fluid ſtate; and that if its fuſion be prolonged much beyond the uſual time, it is rendered leſs fluid, and alſo its coheſion, when it becomes cold, is thereby greatly diminiſhed. The Marquis de Courtivron ſays, that the coheſion may be reſtored to iron in this ſtate, by adding to it ſome vitreſcible earth, which he conſiders as one of the conſtituent parts of iron, and which he thinks is deſtroyed by the fuſion too long continued. That the fuſibility of caſt iron does depend on an admixture of ſome vitreſcible earth, appears probable from the great quantity of ſcoria forced out of iron during its converſion into malleable or forged iron, and from the loſs of fuſibility which it ſuffers nearly in proportion to its loſs of ſcoria. The quantity of iron daily obtained from ſuch a furnace as is above deſcribed, is from two to five tons in twenty-four hours, according to the richneſs and fuſibility of the ore, to the conſtruction of the furnace, to the adjuſtment of the due quantity of flux and of fuel, and to the ſkill employed in conducting the operation.

The

ſubſtances. The vegetable kingdom contains many ſuch ſaline, oily combinations ſoluble in water. All vegetable acids,

The *quality of the iron* is judged by obſerving the appearances during its flowing from the furnace; and when it is fixed and cold. If the fluid iron, while it flows, emits many and large ſparkles; if many brown ſpots appear on it while it is yet red-hot; if when it is fixed and cold, its corners and edges are thick and rough, and its ſurface is ſpotted; it is known to have a red-ſhort quality. If, in flowing, the iron ſeems covered with a thin glaſſy cruſt, and if, when cold, its texture be whitiſh, it is believed to be cold-ſhort. Mr. Reaumur ſays, that dark-colored caſt-iron is more impure than that which is white. The Marquis de Courtivron is of a contrary opinion. But no certain rules for judging of the quality of iron before it be forged can be given. From brittle caſt-iron, ſometimes ductile forged iron is produced. Caſt-iron with brilliant plates and points, when forged, becomes ſometimes red-ſhort and ſometimes cold-ſhort. Large ſhining plates, large cavities called *eyes*, want of ſufficient denſity, are almoſt certain marks of bad iron; but whether it will be cold or red-ſhort cannot be affirmed till it be forged. Whiteneſs of color, brittleneſs, cloſeneſs of texture, and hardneſs, are given to almoſt any caſt-iron by ſudden cooling; and we may obſerve, that in general the whiter the metal is, the harder it is alſo, whether theſe properties proceed from the quality of the iron, or from ſudden cooling; and that, therefore, the darker-colored iron is fitter for being caſt into moulds, becauſe it is capable in ſome meaſure of being filed and poliſhed, eſpecially after it has been expoſed during ſeveral hours to a red-heat in a reverberatory furnace, and very gradually cooled. This operation, called by workmen *annealing*, changes the texture of the metal, renders it ſofter, and more capable of being filed than before, and alſo conſiderably leſs brittle.

Mr. Reaumur found, that by cementing caſt-iron with abſorbent earths in a red-heat, the metal may be rendered ſofter, tougher, and conſequently a fit material for many utenſils formerly made of forged iron. Whether cementation with abſorbent earths gives to caſt-iron a greater degree of theſe properties than the annealing commonly practiſed, has not been yet determined.

In Navarre, and in ſome of the ſouthern parts of France, iron-ore is ſmelted in furnaces much ſmaller, and of a very different conſtruction from thoſe above-deſcribed. A furnace of this kind conſiſts of a wide-mouthed copper-caldron, the inner ſurface of which is lined with maſonry a foot thick. The mouth of the caldron is nearly of an oval or elliptic form. The ſpace or cavity contained by the maſonry is the furnace in which the ore is ſmelted. The depth of this cavity is equal to two feet and a half: the larger diameter of the oval mouth of the cavity is about eight feet,

acids, fluor or concrete; essential salts; saccharine juices; the extractive matter of plants, properly so called, are saponaceous

and its smaller diameter is about six feet: the space of the furnace is gradually contracted towards the bottom, the greatest diameter of which does not exceed six feet: eighteen inches above the bottom is a cylindrical channel in one of the longer sides of the caldron and masonry, through which the nozzle of the bellows passes. This channel, and also the bellows-pipe, are so inclined, that the wind is directed towards the lowest point of the opposite side of the furnace. Another cylindrical channel is in one of the shorter sides of the furnace, at the height of a few inches from the bottom, which is generally kept closed, and is opened occasionally to give passage to the scoria; and above this is a third channel, in the same side of the furnace, through which an iron instrument is occasionally introduced to stir the fluid metal, and to assist, as is said, the separation of the scoria from it. The greatest height of this channel is at its external aperture on the outside of the furnace, and its smaller height is at its internal aperture; so that the instrument may be directed towards the bottom of the furnace; but the second channel below it has a contrary inclination, that when an opening is made, the scoria may flow out of the furnace into a bason placed for its reception. When the furnace is heated sufficiently, the workmen begin to throw into it alternate charges of charcoal, and of ore previously roasted. They take care to throw the charcoal chiefly on that side at which the wind enters, and the ore at the opposite side. At the end of about four hours a mass of iron is collected at the bottom of the furnace, which is generally about six hundred weight: the bellows are then stopt; and when the mass of iron is become solid, the workmen raise it from the bottom of the furnace, and place it, while yet soft, under a large hammer, where it is forged. The iron produced in these furnaces is of the best quality; the quantity is also very considerable, in proportion to the quantity of ore, and to the quantity of fuel employed. In these furnaces no limestone or other substance is used to facilitate the fusion of the ore. We should receive much instruction concerning the smelting of iron-ore, if we knew upon what part of the process or circumstance, the excellence of the iron obtained in these furnaces depends; whether on the quality of the ore; on the disuse of any kind of flux, by which the proportion of vitreous or earthy matter, intermixed with the metallic particles, is diminished; on the forging while the iron is yet soft and hot, as the Marquis de Courtivron thinks; or on some other cause, not observed.

The iron thus produced by smelting ores is very far from being a pure metal; and though its fusibility renders it very useful for the formation of cannon, pots, and a great variety of utensils, yet

naceous ſubſtances, or acid ſoaps. In many of theſe ſoaps, ſuch as eſſential ſalts and vegetable acids, the ſaline part

it wants the ſtrength, toughneſs, and malleability, which it is capable of receiving by further operations.

Caſt-iron ſeems to contain a large quantity of vitreous or earthy matter mixed with the pure iron; which matter is probably the chief cauſe of its fuſibility, brittleneſs, hardneſs, and other properties by which it differs from forged iron. The ſulphur, arſenic, and other impurities of the ores, which are ſometimes contained in caſt-iron, are probably only accidental, and may be the cauſes of the red-ſhort quality, and of other properties of certain kinds of iron: but the earthy matter above-mentioned ſeems principally to diſtinguiſh caſt-iron from forged or malleable iron; for, firſt, by depriving the former of this earthy matter, it is rendered malleable, as in the common proceſs hereafter to be deſcribed; and, ſecondly, by fuſing malleable iron with earthy and vitreſcible matters, it loſes its malleability, and is reſtored to the ſtate and properties of caſt-iron.

The earthy vitreous matter contained in caſt-iron conſiſts probably of ſome of the ferruginous earth or calx of the ore not ſufficiently metalliſed, and alſo of ſome unmetallic earth. Perhaps it is only a part of the ſcoria which adheres to, and is precipitated with, the metallic particles, from which it is more and more ſeparated, as the heat applied is more intenſe, and as the fuſion is longer continued.

To ſeparate theſe impurities from caſt-iron, and to unite the metallic parts more cloſely and compactly, and thus to give it the ductility and tenacity which render this metal more uſeful than any other, are the effects produced by the following operations.

The firſt of theſe operations is a fuſion of the iron, by which much of its impurities is ſeparated in form of ſcoria; and by the ſecond operation, a further and more compleat ſeparation of theſe impurities, and alſo a cloſer compaction of the metallic particles, are effected by the application of mechanical force or preſſure, by means of large hammers.

Some differences in the conſtruction of the forge or furnace, in which the *fuſion* or *refining of caſt-iron* is performed, in the method of conducting the operation, and in ſome other circumſtances, are obſerved to occur in different places. We ſhall deſcribe, from Sueden borgius, the *German method*.

The fuſion of the caſt-iron, which is to be rendered malleable, is performed upon the hearth of a forge ſimilar to that uſed by blackſmiths: at one ſide of this hearth is formed a cavity or fire-place, which is intended to contain the fuel and the iron to be melted: this fire-place is twenty inches long, eighteen inches broad, and twelve or fourteen inches deep; it is bounded on

 three

part predominates over the oily part, and they have therefore been considered rather as salts, than as soaps. But the oil contained

three sides by three plates of cast-iron placed upright; and on the fourth side, which is the front, or that part nearest to which the workmen stand, by a large forge-hammer, through the eye of which the scoria is at certain times allowed to flow. The floor also of the fire-place is another cast-iron plate. The thickness of these plates is from two to four inches. One of the upright side-plates rests against a wall, in an aperture through which a copper tube, called the *tuyere*, is luted with clay. This tube is a kind of case or covering for the pipe of a pair of bellows placed behind the wall, and its direction is therefore parallel to that of the bellows-pipe; but it advances about half a foot further than this pipe into the fire-place; and thus gives greater force to the air, which it keeps concentrated, or prevents the divergency of the air, till it is required to act. The tube rests upon the upper edge of the side-plate which leans against the wall, nearer to the back part than to the front of the fire-place, and in such an oblique direction, that the wind shall be impelled towards the furthest part of the floor of the fire-place, or where this floor is intersected by the opposite side-plate. The obliquity of the tuyere ought to vary according to the quality of the iron: and therefore, in every operation, it may be shifted till its proper position is found. The more nearly its direction approaches to a horizontal plane, the more intense is the heat; but a larger quantity of fuel is consumed than is even proportional to the encrease of heat, because the flame is not then so well confined. When the iron is easily fusible, great heat is not required: the tuyere may then decline considerably from the horizontal plane, and thus fuel may be saved. This tuyere, though made of copper, a metal more easily fusible than iron, is preserved from fusion by the constant passage of cold air through it. It must be carefully kept open, and cleansed from the scoria, which would be apt to block its cavity, by which not only the heat would be too much diminished for the success of the operation, but the tube itself would be melted.

To prepare for the fusion, a quantity of scoria of a former operation is thrown into the fire-place, till one-third part of this be full; and the remaining two-thirds of the fire-place are to be filled with smaller scoria, coal-dust, and sparks ejected from hot iron. These matters, being fusible, form a bath for the reception of the iron when melted. Upon this bed of scoria, the mass of cast-iron to be melted is placed; so that one end of it shall be within the fire-place, opposite to the tuyere, and at the distance of about four or five inches from its aperture; and the other end shall stand without the fire-place, to be pushed in, as the former is melted. The upper side of the mass of iron ought to be in the same horizontal plane

contained in all these compounds is rendered perfectly miscible with water by means of the saline matter, and it is consequently in a state truly saponaceous.

We

plane as the upper part of the orifice of the tuyere, that the wind may, by means of the obliquity of its course, strike upon and pass along the under-side of the mass: but if the iron be difficultly fusible, the tuyere is to be disposed more horizontally, so that the wind shall strike directly upon the mass of iron; and that one part of the blast shall graze along the upper surface, and the other part along the under surface of the iron. The mass of iron weighs generally from two hundred to four hundred pounds. Sometimes two or three smaller masses are put one above another, so as not to touch. When these are of different qualities, the cold-short piece is placed undermost, that being more unfusible than the red-short. The iron being placed, charcoal-powder is thrown on both sides, and coals are accumulated above, so as to cover entirely the iron.

The coals are then to be kindled, and the bellows are made to blow, at first slowly, and afterwards with more and more force. The iron is gradually liquefied, and flows down in drops through the melted scoria to the bottom of the fire-place; during which the workmen frequently turn the iron, so that the end opposed to the blast of wind may be equally exposed to heat, and uniformly fused. While the coals are consumed, more are thrown on, so that the whole may be kept quite covered. During the operation, a workman frequently sounds the bottom and corners of the fire-place, by means of a bar or poker, raises up any mass of metal which he finds adhering to these, and exposes them to the greatest heat, that they may be more perfectly fused.

When all the iron is fused, no more coals are to be added; but the melted mass is to remain half uncovered for some time; during which the iron boils and bubbles, and its surface swells and rises higher and higher. When the iron has risen as high as the upper edge of the fire-place, the coals upon its surface must be removed; and by thus exposing it to cold air, its ebullition and swelling subside. In this state, or coction, the iron is kept during half an hour or more, by adding occasionally pieces of good coal, which maintain a sufficient heat, without covering entire the surface of the mass. During this coction, the workmen allow the orifice of the tuyere to be half stopped up by the scoria, that the air may not blow upon the iron with all its force, by which it would be too much cooled. Accordingly, when they think that the coction has continued sufficiently long, they clear the passage of the tuyere, and the mass is soon cooled by the cold air. At the same time also, they open a passage in the eye of the hammer placed in the front of the fire-place, through which some of the scoria is allowed to flow out. When the iron has become solid, the bel-

We may alſo combine acids directly with oils, and thus may form artificially acid ſoaps. But theſe operations are difficult,

lows are ſtopt, the coals are removed, and the maſs is left during an hour; and then the workmen raiſe it from the fire-place, turn it upſide down, and proceed to the ſecond coction or fuſion of the iron.

For this ſecond operation, the maſs is to be ſo placed, that one part of it ſhall reſt upon the tuyere, and the other upon the ſcoria remaining in the fire-place. This ſcoria is to be diſpoſed in an oblique direction parallel to the tuyere, by which means the wind of the bellows is obliged to paſs all along the under ſide of the maſs of iron. About the ſides of the maſs, charcoal-powder and burnt aſhes are thrown; but towards the tuyere, dry and entire pieces of coals are placed to maintain the fire. When theſe are kindled, more coals are added, and the fire is gradually excited. The workman attends to the direction of the flame, that it paſs equally along the under ſurface of the iron, quite to the further extremity, and that it do not eſcape at the ſides, nor be reverberated back towards the tuyere, by which this copper tube might be melted. During this fuſion, pieces of iron are apt to be ſeparated from the maſs, and to fall down unfuſed to the bottom and corners of the fire-place. Theſe are carefully to be ſearched for, and expoſed to the greateſt heat till they are melted. When the whole maſs is thus brought into perfect fuſion, the coals are removed, and the wind blowing on its ſurface, whirls and diſſipates the ſmall remaining pieces of ſcoria, and ſparks thrown out from the fluid iron. This jet of fire continues about ſeven or eight minutes, and the whole operation about two hours. In this ſecond fuſion the ſcoria is to be thrice removed, by opening a paſſage through the eye of the hammer. The firſt time of removing the ſcoria is about twenty minutes from the kindling of the fire; the ſecond time is about forty minutes after the firſt; and the third time is near the end of the operation.

The maſs is then removed from the hearth, and put upon the ground of the forge, where it is cleanſed from ſcoria, and beat into a more uniform ſhape. It is then placed on an anvil, where, by being forged, it receives a form nearly cubical. This maſs is to be divided into five, ſix, or more pieces, by means of a wedge; and theſe are to be heated and forged till they are reduced to the form of the bars commonly ſold.

In ſome forges, the iron is fuſed only once, and in others it ſuffers three fuſions, by which it is ſaid to be rendered very pure. Where only one fuſion is practiſed, it is called the *French method*. In this, no greater quantity of iron is fuſed at once than is ſufficient to make one bar. The fire-place is of conſiderably leſs dimenſions, and eſpecially is leſs deep than in the German method

difficult, and exhibit many ſingular appearances, according to the ſtate and nature of the acids and oils combined. Vitriolic

thod above deſcribed. The fire is alſo more intenſe, and the proportion of fuel conſumed to the iron is greater. The iron, when melted, is not kept in a ſtate of ebullition, as is above deſcribed; but this ebullition is prevented by ſtirring the fluid maſs with an iron bar, till it is coagulated, and becomes ſolid.

By theſe operations, fuſion and forging, the iron loſes about $\frac{1}{10}$ parts of its former weight, ſometimes more and ſometimes leſs, according to the quality of the caſt-iron employed; it is purified from the vitreous and earthy parts which were intermixed with it, its metallic particles are more cloſely compacted, its texture is changed, and it is rendered more denſe, ſoft and malleable, tough and difficultly fuſible.

The degrees however of theſe qualities vary much in different kinds of iron. Thus ſome iron is tough and malleable, both when it is hot and when it is cold. This is the beſt and moſt uſeful iron. It may be known generally by the equable ſurface of the forged bar, which is free from tranſverſe fiſſures or cracks in the edges, and by a clear, white, ſmall-grained, or rather fibrous texture. Another kind is tough when it is heated, but brittle when it is cold. This is called *cold-ſhort* iron, and is generally known by a texture conſiſting of large, ſhining plates, without any fibres. It is leſs liable to ruſt than other iron. A third kind of iron called *red-ſhort*, is brittle when hot, and malleable when cold. On the ſurface and edges of the bars of this kind of iron, tranſverſe cracks or fiſſures may be ſeen; and its internal color is dull and dark. It is very liable to ruſt. Laſtly, ſome iron is brittle both when hot and when cold.

Moſt authors agree, that the red-ſhort quality of iron proceeds from ſome ſulphur or vitriolic acid being contained in it, becauſe ſulphur is known to produce this effect when added to iron; and becauſe the iron obtained from pyritous and other ſulphurated ores has generally this quality.

The cauſe of the cold-ſhort quality of iron is not ſo well aſcertained. Some imagine that it proceeds from a mixture of arſenic or of antimony. But this opinion ſeems to be improbable, when we conſider that theſe metallic ſubſtances may in a great meaſure be diſſipated by roaſting, whereas the ores which yield a cold-ſhort iron are injured by much roaſting; that no arſenic or antimony are obſervable in moſt, if in any, of theſe ores; and laſtly, that theſe ſemi-metals would render the iron brittle both when hot and when cold. Cramer and other authors impute this vicious quality to a mixture of an unmetallic earth or vitreous matter, and affirm that it may be deſtroyed by cementation with phlogiſton, and by forging. And laſtly, others aſcribe the cold-ſhort quality of iron to a defect of phlogiſton, or, as Sueden borgius

Vitriolic and nitrous acids, especially when well concentrated, act so powerfully upon all drying, sweet, or essential oils,

says, of sulphur. To ascertain the causes of the bad qualities of iron, and to discover practicable remedies, are still desiderata in metallurgy.

In one bar frequently two or more different kinds of iron may be observed, which run all along its whole length; and scarcely a bar is ever found of entirely pure and homogeneous iron. This difference probably proceeds from the practice we have mentioned of mixing different kinds of ores together, in the smelting; and also from the practice of mixing two or more pigs of cast-iron of different qualities in the finery of these; by which means, the red-short and the cold-short qualities of the different kinds are not, as we have already remarked, mutually counteracted or destroyed by each other, but each of these qualities is diminished in the mixed mass of iron, as much as this mass is larger than the part of the mass originally possessed of that quality: That is, if equal parts of red short and of cold-short iron be mixed together; the mixed mass will be only half as red-short as the former part, and half as cold-short as the latter. For these different kinds of iron seem as if they were only capable of being interwoven and diffused through each other, but not of being intimately united or combined.

The quality of forged iron may be known by the texture which appears on breaking a bar. The best and toughest iron is that which has the most fibrous texture, and is of a clear greyish color. This fibrous appearance is given by the resistance which the particles of the iron make to their rupture. The next best iron is that whose texture consists of clear, whitish, small grains, intermixed with fibres. These two kinds are malleable, both when hot and when cold, and have great tenacity. *Cold short iron* is known by a texture consisting of large, shining plates, without fibres: and *red-short iron* is distinguished by its dark dull color, and by the transverse cracks and fissures on the surface and edges of the bars. The quality of iron may be much improved by violent compression, as by forging and rolling; especially when it is not long exposed to too violent heat, which is known to injure, and at length to destroy its metallic properties.

## *Of the* SMELTING *of* TIN-ORES.

The tin-ores commonly smelted, are those which consist of calx of tin combined with calx of arsenic, and sometimes with calx of iron. These are either pure, as the tin-grains, or intermixed with spars, stones, pyrites, ores of copper, iron, or of other metals.

The impure ores must be *cleansed* as much as is possible from all heterogeneous matters. This cleansing is more necessary in ores of

oils, that they produce considerable alterations. Nitrous acid inflames them, or, when not sufficiently concentrated to

of tin than of any other metal, because in the smelting of tin-ores a less intense heat must be given than is sufficient for the scorification of earthy matters, lest the tin be calcined. Tin-ores previously bruised may be cleansed by washing, for which operation their great weight and hardness render them well adapted. If they be intermixed with very hard stones or ferruginous ores, a slight roasting will render these impure matters more friable, and consequently fitter to be separated from the tin-ores. Sometimes these operations, the roasting, contusion, and lotion, must be repeated. By roasting, the ferruginous particles are so far revived, that they may be separated by magnets.

The ore, thus cleansed from adhering heterogeneous matters, is to be *roasted* in an oven or reverberatory furnace with a fire rather intense than long continued, during which it must be frequently stirred to prevent its fusion. By this operation the arsenic is expelled, and in some works is collected in chambers built purposely above the calcining furnace.

Lastly, The ore cleansed and roasted is to be *fused*, and reduced to a metallic state. In this fusion, attention must be given to the following particulars. 1. No more heat is to be applied than is sufficient for the reduction of the ore, because this metal is fusible with very little heat, and is very easily calcinable. 2. To prevent this calcination of the reduced metal, a larger quantity of charcoal is used in this than in most other fusions. 3. The scoria must be frequently removed, lest some of the tin should be involved in it, and the melted metal must be covered with charcoal-powder to prevent the calcination of its surface. 4. No flux or other substance, excepting the scoria of former smeltings which contains some tin, are to be added, to facilitate the fusion.

## SMELTING *of* ORES *of* LEAD.

Ores of lead are either *pure*, that is, containing no mixture of other metal, or they are *mixed* with silver, copper, or pyrites. The methods of treating ores of lead containing silver and copper, are described in the articles SMELTING *of* ORES *of* SILVER *and of* COPPER; and in the former of these articles, an instance is given of the method of smelting the ore of Rammelsberg, which contains all these three metals.

Pure ores of lead, and those which contain so small a quantity only of silver as not to compensate for the expence of extracting the nobler metal, may be smelted in furnaces, and by operations similar to those used at Rammelsberg, or in the following methods. 1. From the lead-ore of *Willach* in *Carinthia*, a great part of the lead

to produce this inflammation, it reduces them, as the vitriolic acid alſo does, into thick, reſinous, and bituminous

lead is obtained by a kind of *eliquation*, during the roaſting of the ore. For this purpoſe, the ore is thrown upon ſeveral ſtrata or layers of wood, placed in a calcining or reverberatory furnace. By kindling this wood, a great part of the lead flows out of the ore, through the layers of fuel, into a baſon placed for its reception. The ore which is thus roaſted is beat into ſmaller pieces, and expoſed to a ſecond operation ſimilar to the former, by which more metal is eliquated; and the remaining ore is afterwards ground, waſhed, and ſmelted in the ordinary method.

The lead of Willach is the pureſt of any known. Schlutter aſcribes its great purity to the method uſed in extracting it, by which the moſt fuſible, and conſequently the pureſt part of the contained lead is ſeparated from any leſs fuſible metal which happens to be mixed with it, and which remains in the roaſted ore. This method requires a very large quantity of wood.

2. In England, lead-ores are ſmelted either *upon a hearth*, or *in a reverberatory furnace*, called *a cupel*.

In the firſt of theſe methods, charcoal is employed as fuel, and the fire is excited by bellows. Small quantities of fuel and of ore are thrown alternately and frequently upon the hearth. The fuſion is very quickly effected; and the lead flows from the hearth as faſt as it is ſeparated from the ore.

3. In the ſecond method practiſed in England, pit-coal is uſed as fuel. The furnace is repreſented by *Fig.* 14. *and* 15. PLATE II. The ore is melted by means of the flame paſſing over its ſurface; its ſulphur is burnt and diſſipated, while the metal is ſeparated from the ſcoria, and collected at the bottom of the furnace. When the ore is well cleanſed and pure, no addition is requiſite; but when it is mixed with calcareous or earthy matrix, a kind of fluor or fuſible ſpar found in the mines is generally added, to render the ſcoria more fluid, and thereby to aſſiſt the precipitation of the metal. When the fuſion has been continued about eight hours, a paſſage in the ſide of the furnace is opened, through which the liquid lead flows into an iron ciſtern. But immediately before the lead is allowed to flow out of the furnace, the workmen throw upon the liquid maſs a quantity of ſlaked quicklime, which renders the ſcoria ſo thick and tenacious, that it may be drawn out of the furnace by rakes. Schlutter mentions this addition of quicklime in the ſmelting of lead-ores in England, but thinks that it is intended to facilitate the fuſion of the ores, whereas it really has a contrary effect, and is never added till near the end of the operation, when the ſcoria is to be raked from the ſurface of the metal.

*Of*

nous compounds. The action of these acids appears less strong upon the fat oils, which do not dry, and are capable of

## *Of the* SMELTING *of* ORES *of* SEMI-METALS.

ANTIMONY is obtained by a kind of eliquation from the minerals containing it, as is described in the article ANTIMONY: and the regulus of antimony is procured from antimony, by the processes described in the same *article*, and in the article REGULUS *of* ANTIMONY.

ARSENIC, SAFFRE, and BISMUTH are obtained generally from one ore, namely, that called *cobalt*. The arsenic of the ore is separated by roasting, and adheres to the internal surface of a chimney, which is extended horizontally about two or three hundred feet in length, and in the sides of which are several doors, by means of which the arsenic, when the operation is finished, may be swept out and collected. These chimneys are generally bent, in a zig-zag direction, that they may better retard and stop the arsenical flowers. These flowers are of various colors, white, grey, red, yellow, according to the quantity of sulphur or other impurity with which they happen to be mixed. They are afterwards purified by repeated sublimations; while some alkaline or other substances are added to detain the sulphur, and to assist the purification.

In the same roasting of the ore by which the arsenic is expelled, the bismuth, or at least the greatest part of this semi-metal which is contained in the ore, being very fusible, and having no disposition to unite with the regulus of cobalt, which remains in the ore, is separated by eliquation.

The remaining part of the roasted ore consists chiefly of calx of regulus of cobalt, which not being volatile, as the arsenic is, nor so easily fusible as bismuth is, has been neither volatilized nor melted. It contains also some bismuth, and a small quantity of arsenic, together with any silver or other fixed metal which happened to be contained in the ore. This roasted ore being reduced to a fine powder, and mixed with three or four times its weight of fine sand, is the powder called *saffre* or *zaffre*. *See* SAFFRE. Or the roasted ore is sometimes fused with about thrice its quantity of pure sand and as much pure potash, by which a blue glass, called *smalt*, is produced (*see* SMALT), and a metallic mass, called *speiss*, is collected at the bottom of the vessel in which the matters are fused. The metallic mass or speiss is composed of very different substances, according to the contents of the ore, and the methods of treating it. The matters which it contains at different times are, nickel, regulus of cobalt, bismuth, arsenic, sulphur, copper, and silver.

Bismuth is seldom procured from any other ores but that of cobalt. It might however be extracted from its proper ores, if a sufficient

of forming with them true acid ſoaps. But all theſe matters have been but ſuperficially examined, and may be conſidered, by perſons deſirous of extending chemical knowledge, as a new ſubject.

SOAP (COMMON). Common ſoap is a combination of oil of olives with fixed alkali rendered cauſtic by

ficient quantity of theſe were found, by the ſame method by which it is obtained from cobalt, namely, by eliquation.

MERCURY, when native and inveloped in much earthy or other matter, from which it cannot be ſeparated merely by waſhing, is diſtilled either by aſcent, or by deſcent. When it is mineraliſed by ſulphur, that is, when it is contained in cinnabar, ſome intermediate ſubſtance, as quicklime, or iron, muſt be added in the diſtillation, to diſengage it from the ſulphur. *See* CINNABAR. The rich ore of Almaden in Spain is a cinnabar, with which a calcareous ſtone happens to be ſo blended, that no addition is required to diſengage the mercury from the ſulphur. The diſtillation is there performed in a furnace conſiſting of two cavities, one of which is placed above another. The lower cavity is the fire-place, and contains the fuel, reſting upon a grate, through the bars of which the air enters, maintains the fire, and paſſes into a chimney, placed at one ſide of the fire-place, immediately above the door through which fuel is to be introduced. The roof of this fire-place, which is vaulted and pierced with ſeveral holes, is alſo the floor of the upper cavity. Into this upper cavity the mineral from which mercury is to be diſtilled is introduced, through a door in one of the ſides of the furnace. In the oppoſite wall of this cavity are eight openings, all at the ſame height. To each of theſe openings is adapted a file of aludels connected and luted together, extending ſixty feet in length. Theſe aludels, which are earthen veſſels open at each end, and wider in the middle than at either extremity, (*ſee* ALUDEL *and* PLATE I.) are ſupported upon an inclined terras; and the aludel of each file, that is moſt diſtant from the furnace, terminates in a chamber built of bricks, which has two doors, and two chimneys.

When the upper cavity is filled ſufficiently with the mineral, a fire is made below, which is continued during twelve or fourteen hours. The heat is communicated through the holes of the vaulted roof of the fire-place to the mineral in the upper cavity, by which means the mercury is volatilized, and its vapor paſſes into the aludels, where much of it is condenſed, and the reſt is diſcharged into the brick-chamber, in which it circulates till it alſo is condenſed. If any air or ſmoke paſſes through the aludels along with the vapor of the mercury, they eſcape through the two chimneys of the chamber. Three days after the operation, when the apparatus is ſufficiently cooled, the aludels are unluted, the doors of the chamber are opened, and the mercury is collected.

quicklime

quicklime. Soap may be made by ſeveral methods, which however all depend upon the ſame principle. The ſoap which is uſed in medicine is made without heat in the following manner.

One part of quicklime and two parts of good Spaniſh ſoda are boiled together, during a ſhort time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phial which is capable of containing an ounce of water, ſhall contain an ounce and three gros of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of ſweet almonds, in a glaſs or ſtone-ware veſſel. The mixture is to be ſtirred from time to time with an iron ſpatula, or with a peſtle, and it ſoon becomes thick and white. The combination is gradually compleated, and in ſeven or eight days a very white and firm ſoap is obtained.

Soap is made with heat in manufactures where large quantities of it are prepared. A lixivium of quicklime and ſoda is made, but is leſs concentrated than that above deſcribed, and only ſo much that it can ſuſtain a freſh egg. A part of this lixivium is to be even diluted, and mixed with an equal weight of oil of olives. The mixture is to be put on a gentle fire, and agitated, that the union may be accelerated. When the mixture begins to unite well, the reſt of the lixivium is to be added to it, and the whole is to be digeſted with a very gentle heat, till the ſoap be completely made. A trial is to be made of it, to examine whether the juſt proportion of oil and alkali has been obſerved. Good ſoap of this kind ought to be firm and very white when cold, not ſubject to become moiſt by expoſure to air, and entirely miſcible with pure water, to which it communicates a milky appearance, but without any drops of oil floating on the ſurface. When the ſoap has not theſe qualities, the combination has not been well made, or the quantity of ſalt or of oil is too great, which faults muſt be corrected.

In ſoft or liquid ſoaps, green or black ſoaps, cheaper oils are employed, as oil of nuts, of hemp, of fiſh, &c. Theſe ſoaps, excepting in conſiſtence, are not eſſentially different from white ſoap.

Any fixed alkalis are much diſpoſed to unite with oils that are not volatile, both vegetable and animal, ſince this union can be made even without heat. The compound reſulting from this union partakes at the ſame time of the properties

of

of oil, and of alkali; but these properties are modified and tempered by each other, according to the general rule of combinations. Alkali formed into soap has not nearly the same acrimony as when it is pure; it is even deprived of almost all its causticity, and its other saline alkaline properties are almost entirely abolished. The same oil contained in soap is less combustible than when pure, from its union with the alkali, which is an uninflammable body. It is miscible or even soluble in water to a certain degree, by means of the alkali. Soap is entirely soluble in spirit of wine, and still better in aqua vitæ sharpened by a little alkaline salt, according to an observation of Mr. Geoffroy.

When oil unites with alkali in the formation of soap, it is little altered in the connexion of its principles, for it may be separated from the alkali by decomposing soap with any acid, and may be obtained nearly in its original state. By the accurate investigation that Mr. Geoffroy has made of soap, by decomposing it thus by means of an acid, he found that two ounces of this compound consist of one ounce three gros and one scruple of oil, one gros and a scruple of marine alkali deprived of all moisture, or twice the quantity of this salt containing the water of its crystallization; and, lastly, two gros and four grains of water. This latter quantity of water is nevertheless variable, according to the condition of the soap; for it may be much more or much less dry.

Concerning the decomposition of soap by means of acids we must observe, first, that all acids, even the weakest vegetable acids, may occasion this decomposition, because every one of them has a greater affinity than oil with fixed alkali. Secondly, these acids, even when united with any basis, excepting a fixed alkali, or the inflammable principle, are capable of occasioning the same decomposition; whence all ammoniacal salts, all salts with basis of earth, and all those with metallic bases, are capable of decomposing soap, in the same manner as disengaged acids are; with this difference, that the oil separated from the fixed alkali, by the acid of these salts, may unite more or less intimately with the substance which was the basis of the neutral salt employed for the decomposition.

Soap may also be decomposed by distillation, as Lemery has done. When first exposed to fire, it yields a phlegm called by him a spirit; which nevertheless is neither acid nor alkaline, but some water which enters into the composition of soap. It becomes more and more colored and

and empyreumatic as the fire is encreaſed, which ſhews that it contains the moſt ſubtle part of the oil. It ſeems even to raiſe along with it, by help of the oil, and action of the fire, a ſmall part of the alkali of the ſoap: for, as the ſame chemiſt obſerves, it occaſions a precipitate in a ſolution of corroſive ſublimate. After this phlegm, the oil riſes altered, preciſely as if it had been diſtilled from quicklime, that is, empyreumatic, ſoluble in ſpirit of wine, at firſt ſufficiently ſubtle and afterwards thicker. An alkaline reſiduous coal remains in the retort, conſiſting chiefly of the mineral alkali contained in the ſoap, and which may be diſengaged from the coal by calcination in an open fire, and obtained in its pure ſtate.

As all oils contain an acid more or leſs combined, which may alſo be more or leſs diſengaged by the oil becoming rancid, by the action of heat, or by combination with other bodies, probably a portion of the alkali of the ſoap is ſaturated with the acid of the oil, eſpecially after the diſtillation of the ſoap. But this matter has not been ſo well examined, that we can affirm any thing concerning it.

Alkaline ſoaps are very uſeful in many arts and trades, and alſo in chemiſtry and medicine. Their principal utility conſiſts in a deterſive quality that they receive from their alkali, which, although it is in ſome meaſure ſaturated with oil, is yet capable of acting upon oily matters, and of rendering them ſaponaceous and miſcible with water. Hence ſoap is very uſeful to cleanſe any ſubſtances from all fat matters with which they happen to be ſoiled. Soap is therefore daily uſed for the waſhing and whitening of linen, for the cleanſing of woolen-cloths from oil, and for whitening ſilk, and freeing it from the reſinous varniſh with which it is naturally covered. Pure alkaline lixiviums being capable of diſſolving oils more effectually than ſoap, might be employed for the ſame purpoſes; but when this activity is not mitigated by oil, as it is in ſoap, they are capable of altering and even of deſtroying entirely by their cauſticity moſt ſubſtances, eſpecially animal matters, as ſilk, wool, and others: whereas ſoap cleanſes from oil almoſt as effectually as pure alkali, without danger of altering or deſtroying, which renders it very uſeful.

Soap furniſhes medicine with a very efficacious and valuable remedy. Till lately, that Mrs. Stephen's lithontriptic remedy has been publiſhed, phyſicians attended little to the medicinal qualities of ſoap. They ſoon found that ſoap,

ſoap, which is the principal ingredient of this famous remedy, is alſo the only one which has any real efficacy. And although this remedy has been found to be inſufficient to diſſolve moſt ſtones of the bladder, yet experience and obſervation have ſufficiently evinced that it can prevent the enlargement, or even the formation, of ſtones in perſons diſpoſed to that diſeaſe; that it can, in a word, attenuate, divide, and expel the ſtoney particles generated in the urinary paſſages, and which are the firſt materials of the ſtone. And accordingly ſoap is frequently uſed ſucceſsfully in theſe caſes. When ſoap was once diſcovered to act ſenſibly on the glue or binding ſubſtance of that urinary ſand, gravel, and even of ſome ſtones, it was naturally ſuppoſed to be capable of acting more powerfully on other thickened matters, which are too frequent cauſes of many obſtinate diſeaſes. Theſe conſiderations have induced the beſt practitioners to preſcribe ſoap as a reſolving, aperitive, and deobſtruent remedy; and we are certain that it has been employed as ſuch with great ſucceſs.

From the properties of ſoap we may know that it muſt be a very effectual and convenient anti-acid. It abſorbs acids as powerfully as pure alkalis and abſorbent earths, without having the cauſticity of the former, and without oppreſſing the ſtomach by its weight, like the latter.

Laſtly, we may perceive that ſoap muſt be one of the beſt of all antidotes to ſtop quickly, and with the leaſt inconvenience, the bad effects of acid corroſive poiſons, as aqua-fortis, corroſive ſublimate, &c.

SOAP (STARKEY's). This preparation is a combination of fixed vegetable alkali with eſſential oil of turpentine. It is named from the inventor, a chemiſt, called Starkey, who endeavouring to reſolve the problem of the volatiliſation of ſalt of tartar, combined that alkali with ſeveral ſubſtances, and particularly with oil of turpentine, and remarked that from this latter mixture a ſaponaceous compound was formed, which has been ſuppoſed to poſſeſs many medicinal virtues. It enters into the compoſition of pills, named alſo from Starkey. The belief of its good qualities has induced perſons to continue the preparation of this ſoap, and to endeavour, but without ſucceſs, to improve the proceſs.

Although fixed alkalis are not abſolutely inactive upon eſſential oils, they cannot however unite as eaſily with theſe, as with ſweet oils, which are not volatile. If we attempt to combine any eſſential oil, and particularly oil of turpentine,

pentine, with liquid fixed alkali, as in the preparation of ordinary ſoap, we ſhall ſoon find that theſe two ſubſtances cannot unite, or only imperfectly, and in long time. Starkey found no other expedient for the preparation of his ſoap than time and patience. His method, which is perhaps the beſt of all, conſiſts in putting dry alkali into a matraſs, and pouring upon it eſſential oil of turpentine to a height equal to the breadth of two or three fingers. In a long time the combination was compleated. In five or ſix months a part of the alkali and oil are thus combined together, and form a ſort of white ſaponaceous compound. This ſoap muſt be ſeparated from the mixture, and more of it will be afterwards formed in the ſame manner.

Shorter methods have been ſearched for the preparation of this ſoap, by ſeveral chemiſts; and amongſt theſe is the illuſtrious Stahl; who conſidering water as part of the combination of every ſoap, and even that it is a medium by which the ſalt and oil are united together, directs, that after having mixed oil of turpentine with very hot alkali, and having ſhook them together, this mixture ſhould be expoſed in a moiſt place, that all the portion of alkali which does not unite with the oil may deliquiate, and be ſeparated from the part of the mixture that is combined; that this alkali ſhould then be dried, and new oil poured upon it, as at firſt; and, laſtly, that this method ſhould be continued till the whole be reduced into ſoap; and thus the operation will, as he affirms, be greatly ſhortened. Nevertheleſs, later chemiſts, not ſatisfied with this method of Stahl, have endeavoured to ſimplify ſtill more this operation. Mr. Rouelle the younger has publiſhed, in the *Journal de Medicine*, that he has diſcovered a more expeditious method than all thoſe hitherto known for the preparation of this ſoap. Mr. Beaumé has alſo publiſhed in the *Gazette de Medicine* a method of making it in a few hours. It conſiſts in triturating, during a long time, alkaline ſalt upon a porphyry, and in adding to this ſalt, during the trituration, oil of turpentine. According to this able chemiſt, the thick reſinous part only of this oil can truly combine with fixed alkali: and this combination is effected only while the more volatile and attenuated part of the oil is diſſipated. For which reaſon, according to him, a very great quantity of oil of turpentine is requiſite for the formation of Starkey's ſoap, which quantity of oil is indeterminate, as, the more volatile and ethereal it is, the more of it is required; and alſo the trituration upon the porphyry, by promoting the evaporation of the ſubtle part of

the oil, accelerates considerably the operation of Starkey's soap.

Another artist says, in the *Gazette de Medicine*, that the operation may be much abridged, by adding to the new mixture a certain quantity of this soap ready made; which corresponds with Mr. Beaumé's opinion. Lastly, Mr. Beaumé has found, that the addition of a little turpentine, or of ordinary soap, considerably abridges the operation; and this also confirms his opinion, which seems to be very probable. We do not mean to blame the zeal of these chemists in making so many attempts to find a method of preparing this soap quickly, but we confess that the importance of the object does not seem adequate to their trouble. For, in fact, what does it signify whether this soap, not used in the arts, and but little in medicine, be quickly or slowly made? The essential point is not that it be quickly, but well done.

And to speak our sentiments freely, this preparation seems to be uncertain and ill-chosen. For, besides that the true soap of Starkey, that is, the intimate combination of ethereal oil of turpentine with fixed alkali, according to the usual idea of it, is a thing probably impossible; we believe that we may affirm, that the saponaceous compounds obtained by any method of mixing oil of turpentine with fixed alkali do not long remain in the same state, and by time necessarily undergo perpetual alterations.

To be fully convinced of this truth, we may compare together not only these soaps made by different processes, but also the same soap, a longer or shorter time after it has been made, and we shall find considerable differences in their color, smell, and consistence. We shall find that those deliquiate, and are partly resolved into liquor by the air, that have been made with a too ethereal oil, which is incapable of saturating well the fixed alkali; that others acquire by time a pitchy, yellowish, semi-transparent and resinous appearance, which contain too large a quantity of thick residuum of oil of turpentine. Those soaps which seem to be the best made, which contain a proper quantity of oil of turpentine, which are neither too ethereal nor too thick, preserve longer their white color and the consistence of true soap: But they nevertheless participate more or less of the faults we have mentioned. Lastly, all these soaps are liable to contain a considerable quantity of a sort of neutral salt, formed by the acid of the oil of turpentine, united with a part of the alkali of the soap. This salt

crystallizes

cryſtallizes upon the ſurface, and even within the ſoap, which in time becomes quite penetrated and ſtuck all over with a ſaline efflorefcence. Thefe bad qualities and alterations of Starkey's ſoap cannot be avoided by any method, as they depend on the nature of eſſential oils, which we cannot change. Thefe ſoaps are known to contain a volatile and ſurperficially combined acid, which unfolds itſelf more and more, or which is engaged more intimately with a portion of oil, to which it gives a thicker conſiſtence. We are no leſs certain that the moſt ethereal part of eſſential oils, or their ſpiritus rector, is ſo volatile, that however attentive we may be to preſerve it, it will gradually diſſipate in time: in a word, we know from experience, that all eſſential oils are drying, and are much more ſpontaneouſly alterable than any others; and that thefe ſpontaneous alterations cannot be prevented by the imperfect combination which they are capable of forming with an alkali. On the contrary, this alkali, by abſorbing their acid, and by facilitating the diſſipation of their ethereal part, with which the alkali is not capable of forming a true union, can only haſten the alterations to which the oil is naturally diſpoſed.

From all this we ought to conclude, that Starkey's ſoap is a difficult, uncertain, variable preparation, which is continually changing its nature, and conſequently its medicinal virtues. This latter inconvenience, although it were the only one, would be ſufficient to make us reject this preparation. And therefore, as is probable, a ſaponaceous ſubſtance, partaking of the properties of fixed alkali and of an eſſential oil, would be uſeful in medicine; ordinary ſoap, incorporated extemporaneouſly with any quantity of eſſential oil which ſhall be judged proper, might be ſubſtituted inſtead of Starkey's ſoap. *See* OILS (ESSENTIAL).

SOAP-ROCK. *or* SOAP-STONE. *See* STEATITES.

SODA. *(r)*

SOLUTION. Solution conſiſts in an union formed by the integrant parts of one body with the integrant parts of another body of a different nature; and as a new compound is the reſult of this union, we hence ſee that ſolution is nothing elſe than the act of combination.

*(r) Soda* is a name given to the maritime plant *kali*, from the aſhes of which a conſiderable quantity of mineral alkali may be obtained; and alſo to the aſhes themſelves, or to an impure alkaline ſalt extracted from thefe. *See* KALI *and* ALKALI (MINERAL).

As the integrant parts of one body cannot unite with those of another, while they adhere together; therefore solution cannot be made till the aggregation of one of the two bodies at least is broken. And as bodies whose aggregation is broken are necessarily in a state of fluidity or of vapors, an axiom has been formed, *Corpora non agunt nisi sint fluida*, or, Bodies do not act unless they be fluid.

The two bodies which unite in solution are usually distinguished by two different names. That body is generally called the *solvent* which by its fluidity or acrimony appears to be active; and the body which from its want of taste or from its solidity appears to be altogether passive, is said to be *dissolved*. Thus, for example, when metal or marble is dissolved in aqua-fortis, these solid bodies are considered as being *dissolved*, and aqua-fortis as the *solvent*. But these expressions ought not to be taken literally, for they would give a very false idea of what really happens in solution. On the contrary, we are certain that any two bodies, which unite together in solution, reciprocally exercise their action one upon another, and that the union which results from it is only the effect of the mutual tendency which they have to each other: that thus, in the examples mentioned, the marble and metal act as much upon the nitrous acid as this does upon them; and that, if they differ in this respect, that body, whose specific gravity is greatest, acts most strongly. Mr. Gellert, considering the thing in this point of view, affects to represent as *solvents* the bodies which are generally considered as *dissolved*, and says, for instance, that *sand dissolves alkali*. Provided that we understand that the action of the combining bodies is mutual, it signifies little that we name the one *solvent*, and the other the body *dissolved:* and even as the word *solution*, taken in its most proper signification, expresses the separation of the integrant parts of a body, we seem to speak more clearly and accurately when we call that body the *solvent*, whose integrant parts are already separated before the solution, and that the *body dissolved* whose integrant parts are only disunited during the act of solution.

As the solution cannot be effected unless one of the two bodies at least be fluid, and as solid bodies only become fluid by the interposition of the parts of some other fluid, such as water and watery liquors, or fire, hence the solution may be made either by the *humid* or by the *dry way*. The solutions in which the integrant parts of one of the two

two bodies, or of both, are diſtributed in an aqueous fluid, as, for inſtance, thoſe of acids, are *ſolutions by the humid way*; and thoſe ſolutions in which one or both bodies are rendered fluid by fire, as in vitrification, and in allays of metals with each other, are *ſolutions in the dry way*.

The ſolution of bodies is not perfect, unleſs each of the integrant parts of one body are united to one of the integrant parts of another. Hence if one of the two bodies be tranſparent, we ought to have, after the mutual ſolution, a tranſparent compound, as happens in the ſolutions of calcareous ſtones and acids, and of thoſe of earths by alkalis. As therefore the ſolution of ſoap in water is always a little opake and milky, it ought not to be conſidered as complete. The ſame may be ſaid of glaſſes that are not perfectly tranſparent. Their want of tranſparency always proceeds from the parts of the ſand or flint not having been ſufficiently diſſolved by the ſalt, or from their containing ſome refractory matters, ſuch as certain metallic calxes, particularly calx of tin, which reſiſt the action of ſalts.

As the ſolution of two bodies by one another can only be effected by the attraction or tendency which their integrant parts have to each other, hence, after the ſolution, theſe parts are found to adhere together: hence alſo heavy bodies may be ſuſpended in the thinneſt and lighteſt liquids, when they are truly diſſolved by each other. For inſtance, corroſive ſublimate, which is very heavy, may be ſuſpended by ſpirit of wine, which keeps it diſſolved, although this liquor be very light. *See* COMPOSITION *and* COMBINATION.

SOOT. Soot is a collection of ſubſtances formed by the matter of the flame of inflammable bodies, but which have eſcaped combuſtion, from not having ſufficient contact with the air. This matter, which fixes itſelf to the internal ſurface of chimneys, is always of a black color, more or leſs browniſh. This color it receives from an oil that is burnt, and half reduced to the ſtate of coal.

As all inflammable bodies undergo a total decompoſition during their inflammation, all the volatile principles which they contain, and even a part of the fixed principles, by means of thoſe which are volatile, are raiſed in vapors, ſome part of which burns with flame, is totally diſſipated and deſtroyed, and another part is ſublimed and adheres to the firſt cold bodies which it meets.

Soot is, as we have now obſerved, the portion of flame which is reduced to black ſmoke, and which has not been

inflamed from want of ſufficient contact with air. For if the vapors exhaling from an inflammable body ſtrongly heated were ſo rarefied, that each of their parts ſhould be altogether ſurrounded by air, they would all burn with flame, and then we ſhould have no ſmoke or ſoot, or at leaſt this ſoot would not be black, and would contain nothing inflammable. For which reaſon, the greater quantity of air is admitted amongſt bodies which burn with flame, the leſs ſmoke and ſoot we have; and alſo, the ſoot proceeding even from bodies of the ſame kind muſt be very different according to the manner in which they are burnt. In general, we can ſay nothing that will be conſtantly applicable to the nature and principles of ſoot, as its differences ariſe not only from the cauſes above-mentioned, but alſo from the nature of the inflammable ſubſtances which produce it. Thus vegetables, from which little or no volatile alkali is obtained, muſt furniſh a ſoot different from that of animal matters; and the ſoot of a pure oil muſt be different from that of a plant containing all its principles. But theſe differences have not yet been obſerved, becauſe chemiſts have not attended to this ſubject.

We know only that the ordinary ſoot of chimneys has an acrid, bitter, empyreumatic, and diſagreeable taſte; that water can extract from it a duſky-colored matter, which ſhews that it contains ſaline, oily, ſaponaceous parts; that it is capable of being again burnt very vividly and with much flame, as when chimneys are ſet on fire.

If this ſoot be diſtilled in a retort, we obtain from it phlegm, volatile alkali, partly concrete and partly liquid, a black empyreumatic oil, and in the retort much coal remains, from which fixed alkali may be extracted by incineration and lixiviation. Some acid alſo may poſſibly be obtainable from certain ſoots; and generally towards the end of the diſtillation, when the heat is ſtrong, a little ſal ammoniac is ſublimed.

As every ſoot, even that which proceeds from vegetable matters, contains a good deal of volatile alkali, we may infer, that the principles of vegetables ſuffer, by combuſtion in an open fire, changes ſimilar to thoſe occaſioned by putrefaction. Beſides, the quantity of fixed coal which remains after the diſtillation of ſoot, and which furniſhes a fixed alkali, together with much earth, by incineration, ſhows that a very conſiderable quantity of the fixed principles of inflammable bodies is carried off, and even raiſed to a great height, by means of their combuſtion with flame: but,

but, as we have ſaid, ſoots are very different; and the matter is but little known, and requires further reſearches.

SORREL. (s)

SPAR. Naturaliſts and chemiſts have given this name to certain cryſtallized ſtones, more or leſs tranſparent, which generally do not ſtrike fire with ſteel, and which are found plentifully within the earth, but more eſpecially in mines of metals.

Under this general name many ſtones are comprehended; becauſe they have the general properties we have mentioned, and becauſe they reſemble each other by the form of their cryſtallization, in which we always perceive ſhining plates, like mirrors; but ſome of theſe ſtones are very different from others.

Some ſpars are entirely ſoluble with effervescence in acids, forming ſelenites with vitriolic acid, deliqueſcent ſalts with nitrous and marine acids, and convertible into quicklime by calcination. Theſe ſtones are juſtly called *calcareous ſpars.*

Others, although entirely ſimilar to theſe in appearance, do not effervesce with acids, are calcinable as gypſum and ſelenites are, and are, in fact, true ſelenites compoſed of vitriolic acid and calcareous earths. Theſe ſpars are eſſentially different from the former, and are *gypſeous* or *ſelenitic ſpars.*

Other ſpars are neither calcareous nor ſelenetic, do not loſe their tranſparency in the fire, and ſeem to be of the nature of *talc.*

Laſtly, a kind of ſtone, cryſtallized in mirror-like plates like a true ſpar, is almoſt opake, is indiſſoluble by acids, and is ſo much harder than all other ſpars as to be capable of ſtriking fire with ſteel. This ſtone is fuſible without addition, by the action of a violent fire, into a ſemi-tranſparent white matter. This ſeems to be the kind that Mr. Wallerius, Mr. Pott, and other German authors, call *fuſible ſpars.* They alſo mention another ſpar which is compact, breaks like glaſs, and melts without addition.

(s) SORREL. The leaves of this plant contain an acid ſalt which may be obtained from the expreſſed juice by cryſtallization. From twenty pounds of freſh ſorrel-leaves Neuman expreſſed ſix pounds of juice, from which two ounces, two drams and one ſcruple of cryſtallized ſalt, together with two ounces and ſix drams of an impure ſaline maſs, were obtained. *See* SALT (ESSENTIAL) *of* SORREL.

From the deſcriptions given by moſt authors we cannot eaſily diſcover what they mean by fuſible ſpar, and by *quartz-ſpar*. Theſe matters have not yet been ſufficiently examined.

From the properties of all the ſubſtances called ſpars we may conjecture, that they are ſtones of all kinds, very different from each other, which being formed in metallic grounds, have contracted, either by the mixture of ſome metallic earths, or even by a metalliſation begun in their own earth, ſome properties common to all, or, at leaſt, to the greateſt number.

Theſe properties are, 1. A certain form of ſhining laminæ in their cryſtallization, which appears even in thoſe, the figure of whoſe cryſtals ſeems leaſt diſpoſed to receive this form, as in thoſe which are ſtriated; for ſparry laminæ are diſtinguiſhable at the extremities of the ſtriæ, or bundles of ſtriæ, of which theſe ſpars are compoſed.

2. A greater ſpecific gravity than of all other ſtones. Some ſpars, eſpecially thoſe called *heavy ſpars*, are ſo very heavy, that they come near in this reſpect to metals.

3. A greater fuſibility than of other ſtones; for, beſides thoſe ſpars which are fuſible without addition, the mixture of ſpars facilitates the fuſion of moſt other earths and ſtones, and they are accordingly uſed as fluxes in the ſmelting of moſt metallic ores. Probably for this reaſon theſe ſtones have been called *fluors* by many mineralogiſts and metallurgiſts.

Laſtly, many ſpars are found colored by metallic principles, and imitate the colors of the ſeveral precious ſtones, though they are leſs beautiful and vivid.

We ſhall not enter into a more particular detail concerning ſpars, becauſe what is further known about them rather belongs to natural hiſtory, than to chemiſtry; beſides that our knowledge of ſpars is not very diſtinct. *(t)*

SPELTER.

*(t)* SPARS. This name is given to many ſtones of different properties and appearances, which do not poſſeſs conſtantly any one common character or mark by which they may be certainly diſtinguiſhed from other ſtones. In general, we may obſerve, that they are moſt frequently found in mines, and that they generally conſiſt of ſmooth and ſhining plates or laminæ; that ſome are tranſparent, and others opake; that ſome are colorleſs, and others are colored; that they are cryſtallized in various determinate figures, or poſſeſs no determinate ſhape; and, laſtly, that they differ ſo much in hardneſs, denſity, degree of fuſibility, and

LTER. Zinc is ſometimes ſo called. *See*

SPERMA-

ir moſt eſſential chemical properties, that they cannot red as forming a diſtinct claſs of foſſil ſubſtances. We wonder, therefore, that authors, eſpecially thoſe who een much accuſtomed to the examination of foſſil bo- d have given very confuſed and indiſtinct deſcriptions Many of them have not been ſufficiently examined; but which we have acquired ſome knowledge, we ſhall en- diſtinguiſh into their ſeveral different kinds.

eral ſtones to which the name of ſpar has been given are, *ous*, the *gypſeous*, the *fluors*, and *felt ſpar*.

*areous ſpars* are ſoft, heavy ſtones, which have the com- nical properties of calcareous earth. Their texture is . Some of them have no determinate figure, and n their form are called *rhomboidal*. Some ſpars, called *-ſpar*, have a pyramidal figure; but when theſe are heir fragments ſhow that they alſo conſiſt of rhomboidal

homboidal ſpars are tranſparent, others are opake; ſome ſs, and others are colored; laſtly, ſome of them have property of refracting doubly the rays of light which gh them, and thereby of repreſenting any object; as, ce, the letters of a book, ſeen through it, double. has been called *iſland cryſtal*, or *refracting ſpar*. Its hat of an oblique parallelopiped, contained within ſix ram ſides and eight ſolid angles. Each of the obtuſe the parallelograms is 101 degrees and 52 minutes; and e acute angles is 78 degrees and 8 minutes. Theſe are ſions given by Sir Iſaac Newton of the angles of the e refracting ſpar.

ous ſpars may be diſtinguiſhed from others by effervef- acids.

*ſeous or ſelenitic ſpars*. Theſe are gypſeous earth, di- yſtallized. The form of the cryſtals is rhomboidal. alſo called *ſelenites* and *glacies Mariæ*. Sometimes theſe he other forms. They are very heavy. *See* SELENITES, CIES MARIÆ.

argraaf has ſhewn, that under this claſs are to be com- l thoſe white opake ſpars, which by calcination with in- e matters are capable of receiving a phoſphoric quality, that of the Bolognian ſtone, which he alſo ſhews, is a ſpar. *See the article* PHOSPHORIC STONES.

*ors*. Of the ſpars called Fluors, we have treated under e FLUOR.

4. *Fleet-*

SPERMA-CETI. *(u)*

SPIRIT. The name of ſpirit is given in general to all liquors obtained from ſubſtances by diſtillation. Spirits are of three principal kinds, namely, *inflammable ſpirits*, *acid ſpirits*, and *alkaline ſpirits*.

The claſs of inflammable ſpirits includes the moſt volatile and thinneſt part of eſſential oils; the principle of ſmell, or the *ſpiritus rector* of plants; and *ardent ſpirits*, or the ſpirit obtained from wine, beer, and all liquors which have undergone the *ſpirituous fermentation*.

In the ſecond claſs are all acids obtained by diſtillation of minerals, vegetables, and of animals. Such are, 1. The acids of ſulphur, vitriol, alum, all which are the ſame acid, namely, the vitriolic, and the acids of nitre and of common ſalt. They are called *ſpirit of ſulphur*, *ſpirit of vitriol*, *ſpirit of nitre*, &c. without ſpecifying that they are acids. 2. The acids of *vinegar*, and of all liquors which have undergone the *acetous fermentation*, and the acids obtained in the diſtillation of vegetables, and of certain animals, as flies, ants, &c. Theſe ſpirits are commonly called *acid ſpirits*, as the *acid ſpirit of guiacum*, the *acid ſpirit of ants*, &c. becauſe the ſubſtances which furniſh them yield alſo ſpirits that are not acid.

*2. Felt-ſpar, Spatum ſcintillans.* This ſtone differs from all the foregoing, in being ſo hard as to be capable of ſtriking ignited ſparks from ſteel. For which reaſon it is referred by Cronſtedt to the ſiliceous claſs of earths, and is by him called *rhombic quartz*; becauſe the particles of which it conſiſts ſeem to be parallelopipeds, each of which is contained within ſix rhombic or rhomboidal ſides. Its colors are various, white, grey, and red.

Several other foſſil ſubſtances conſiſt of large plates, and are therefore ſaid to have a *ſparry texture*. Such are ſome kinds of talks, of horn-blend, of quartz, of amianthus, and ſome calciform ores of metals.

*(u)* SPERMA-CETI is a white, flaky, unctuous ſubſtance, obtained from the heads of whales. It is altogether ſoluble in oils; but is not capable of being diſſolved by cauſtic alkalis, and of forming ſoaps, as other oily matters may. By diſtillation it may be entirely raiſed, without leaving any reſiduum. From four ounces of ſperma-ceti three ounces and a half of oil, and a drachm and a half of phlegm, were diſtilled. The oil diſtilled is not black, fetid, and empyreumatic, like that of other animal ſubſtances, but clear, yellowiſh, and of the conſiſtence of butter. Sugar does not render ſperma-ceti perfectly miſcible with water: but this may be better done by means of yolks of eggs. *Neuman.*

Laſtly,

in the third clafs are liquid volatile alkalis, ob-
m fal ammoniac, from all vegetable matters which
ergone a complete putrefaction, and from all ani-
ters. They are generally called *fpirits* only,
fpecifying their alkaline quality. Thus we fay,
*irit of fal ammoniac, fpirit of hartfhorn*, &c. As
hefe fubftances, particularly fal ammohiac, contain
cid which may be obtained from them, we ought,
mention this fpirit, to fpecify its acid quality, and
t, for inftance, *acid fpirit of fal ammoniac.*

IT (ARDENT). Ardent fpirit, called alfo
*wine*, becaufe it can be only obtained from fub-
hich have undergone the vinous fermentation, is a
t, very volatile, very fluid liquor, perfectly white
id, and of a ftrong, penetrating, agreeable tafte
l.

fpirit may be eafily inflamed, without being pre-
eated. Its flame is light, white in the center, blue
es, and not very luminous. It is not accompanied
fmoke or foot. It burns without noife, and with-
fuffocating or other vapors.

of wine perfectly pure, for of that I fpeak, burns
with concurrence of free air, without leaving
veftige of coal, or of any faline, earthy or other
.

ugh fpirit of wine be altogether inflammable, it is
lefs mifcible with water without any intermediate
e, and in all proportions, which is a fpecific cha-
f this liquor; for it is the only fubftance of the
own which is poffeffed of thefe properties.

rit of wine be expofed to heat in clofe veffels, it does
me, but is eafily reduced into vapors which pafs in
on. Thefe vapors, when collected, are entirely the
rit of wine as before diftillation, without having re-
ny alteration or decompofition, however frequently
ation may have been repeated.

ker fays, that if fpirit of wine be burnt in a tubu-
tort, to which a large glafs receiver has been adapt-
vill be changed into a very fubtle vapor, which con-
n the receiver, and forms a liquor fimilar to pure

haave affirms, that when the vapor of burning fpirit
is collected by an apparatus of proper veffels, it
ng but very pure water.

The

The following are the principal properties of ſpirit of wine relatively to other ſubſtances.

It ſeems to have no ſenſible action upon earths, or upon metallic matters, nor even upon many neutral ſalts; (x) but

(x) The degrees of ſolubility of many neutral ſalts in ſpirit of wine are exactly aſcertained by experiments made by M. Macquer, of which an account is publiſhed in the Memoirs of the Turin Academy. The ſpirit of wine he employed was carefully freed from ſuperabundant phlegm by repeated rectifications, without addition of any intermediate ſubſtance. A phial which contained one Paris ounce of diſtilled water when Reaumur's thermometer was at ſix degrees above the freezing point, contained of this rectified ſpirit ſix gros and fifty-four grains. The ſalts employed in his experiments were previouſly deprived of their water of cryſtallization by a careful drying. He poured into a matraſs, upon each of the ſalts thus prepared, half an ounce of his ſpirit of wine, and ſet the matraſs in a ſand-bath. When the ſpirit began to boil, he filtrated it while it was hot, and left it to cool that he might obſerve the cryſtallizations which took place. He then evaporated the ſpirit and weighed the ſaline reſiduums. He repeated theſe experiments a ſecond time, with this difference, that inſtead of evaporating the ſpirit in which the ſalt had been digeſted, he ſet fire to it in order to examine the phenomena which its flame might exhibit. The principal reſults of his experiments are ſubjoined.

| *Quantity* of | *Salts* ſoluble in 288 grains of Spirit | Peculiar Phenomena of of the *Flame*. |
|---|---|---|
| 0 Grains | Vitriolated tartar | None. |
| 4 —— | Nitre | Flame larger, higher, more ardent, yellow and luminous. |
| 5 —— | Salt of Sylvius | Large, ardent, yellow and luminous. |
| 0 —— | Glauber's ſalt | Conſiderably red. |
| 15 —— | Cubic nitre | Yellow, luminous, detonating. |
| 0 —— | Common ſalt | Larger, more ardent, and reddiſh. |
| 0 —— | Vitriolic ammoniac | None. |
| 108 —— | Nitrous ammoniac | Whiter, more luminous. |
| 24 —— | Sal ammoniac | None. |
| 0 —— | Selenites | None. |
| 288 —— | Nitre with calcareous baſis | Larger, more luminous, red, and decrepitating. |
| 288 —— | Marine ſalt with calcareous baſis | Like that of the calcareous nitre. |
| 0 —— | Vitriol of ſilver | None. |

48 —

acids, alkalis, and many oily ſubſtances it exhi-
arkable phenomena.

of wine unites with all acids; and by this union
ty of theſe is diminiſhed. Accordingly, the acids
nbined with ſpirit of wine are called *dulcified acids.*
TER *of* RABEL; SPIRIT *of* NITRE, *and* SPIRIT *of*
DULCIFIED).

hen it is mixed in certain proportions with concen-
cids, and diſtilled, at leaſt, with moſt of them, it
eives from them, and produces upon them the fol-
lterations.

of all, ſome of it paſſes over dephlegmated as much
be without being eſſentially altered; afterwards it
t of the water eſſential to it; conſequently the na-
the remaining part is changed, and it is converted
quor, the properties of which ſhew, that it is as
proximated to the nature of oil as it is removed
nt of ſpirit of wine. This liquor, which is very
l very volatile, is called *ether*, which is, according
we have ſaid, a ſubſtance exactly intermediate be-
dent ſpirit and oil. *See* ETHER.

this, the ſpirit of wine, or its mixture with acids,
all the characters of oil, or rather becomes a ge-
l.

| | | |
|---|---|---|
| — | Nitre of ſilver | |
| — | Luna cornea | None. |
| — | Vitriol of mercury | None. |
| — | Nitre of mercury | None. |
| — | Corroſive ſublimate | Large, yellow, luminous, and decrepitating. |
| — | Martial vitriol | None. |
| — | Martial nitre | Red, and decrepitating. |
| — | Martial marine ſalt | More white, luminous, and ſparkling. |
| — | Vitriol of copper | None. |
| — | Cupreous nitre | More white, luminous, and green, much ſmoke. The ſalin reſiduum became black and burnt. |
| — | Cupreous marine ſalt | Fine green, white and red fulgurations. |

cquer accompanies the relation of his experiments with
licious reflections not eaſily capable of abridgement.

4 grains were an acid matter. This ſalt could not be dried without
on.

Acids,

Acids on their ſides receive from ſpirit of wine, eſpecially after the formation of ether, all the alterations which they uſually receive from oils with which they have been treated and diſtilled. *See* ETHER.

Very ſtrong and dephlegmated alkalis act ſingularly upon ſpirit of wine, and are even capable of decompoſing it, when aſſiſted by a certain degree of heat. They deprive it, firſt, of all its ſuperabundant water, then of the water it contains as a principle, and, laſtly, they reduce it to the condition of a true oil, without making it paſs, as acids do, through the intermediate ſtate of ether. *See* TINCTURE *of* SALT *of* TARTAR.

Spirit of wine is commonly conſidered as the ſolvent of oils and of oily matters; but properly it is the ſolvent only of one kind of oils. Theſe are the eſſential oils and their concretions, ſuch as balſams and reſins; all which ſpirit of wine can diſſolve. It attacks neither the fat oils nor the oily concretions analogous to them, as wax, butter, fat of animals, nor even certain ſubſtances which ſeem to partake more of the nature of true reſin, as copal and bitumens. *See* OILS *and* RESINS.

When ſpirit of wine keeps an oily matter diſſolved, it may be ſeparated by diſtillation, if the oily matter be not volatile, or by diluting the ſolution with a large quantity of water. This water, with which the ſpirit has a greater affinity than with oil, unites with it, and renders it incapable of keeping the oil diſſolved. Hence the oily matter ſeparates at firſt in very ſmall globules, which are diſperſed through the liquor, and give it the white appearance of an emulſion; and theſe globules afterwards collect, forming more conſiderable maſſes, by which the liquor is rendered very clear.

Theſe properties of ſpirit of wine are advantageouſly applied to extract the eſſential oils and reſins of vegetable matters.

Accordingly, by digeſting in ſpirit of wine aromatic plants, for inſtance, thyme, lavender, roſemary, &c. a ſpirituous liquor is obtained, impregnated with the principle of the ſmell, and with the eſſential oil of the plants. Theſe ſpirituous aromatic waters, made by infuſion, ſerve for ſeveral purpoſes in medicine. They are generally colored by a part of the extractive matter of the vegetables, which the ſpirit of wine alſo diſſolves, or by ſubſtances of different colors which reſide in the reſinous ſubſtance. They have hence been called *tinctures*. *See* TINCTURE.

By

ſtillation is obtained from ſpirituous tinctures a wine much impregnated with the principle of ſmell, the thinneſt and moſt volatile part of the eſſential t free from all extracting or coloring matter; hese latter are not ſufficiently volatile to riſe with wine. This ſpirit of wine is called by the general *matic ſpirituous diſtilled water*, or only by the name , added to the name of the plant employed: hence es of *lavender-water*, *roſemary-water*, &c. Waters made of ſeveral plants, and are diſtinguiſhed by r names, as *vulnerary-water*, *imperial-water*, &c. aters are intended for medicine and for the toilette. find the details of theſe preparations in books on y, and particularly in *Mr. Beaumé's Elements of* .

a tincture has been diſtilled, we may find at the f the veſſel the reſinous and extractive part which t of wine had diſſolved. Theſe ſubſtances have ne ſcarcely any alteration, becauſe they have been only to a very mild heat. Theſe are extracts of ade by ſpirit of wine. *See* EXTRACT.

tead of ſubjecting to diſtillation the ſpirituous tinc- vegetables, they be diluted with a large quantity , the reſinous part may be very well obtained pure rate from the extractive part. This latter part ually ſoluble in water as in ſpirit, remains diſſolved tanding the addition of water, while the former arates, as we have ſaid, and forms a reſinous

s method are obtained the reſins of jalap, of ſcam- f guiacum, and of many other vegetable matters; e reſins, not having undergone the action of fire, ltered, but remain in the ſame ſtate in which they the vegetables.

of wine diſſolves alſo very well certain ſalts, as ſal c, corroſive ſublimate, ſedative ſalt, and perhaps hers which we do not know of; becauſe this as not been much examined: but this ſpirit has no action upon other ſalts, as common ſalt, Glau- , nitre, concrete volatile alkali, *&c.* It does not natters purely gummy and gelatinous, or, at leaſt, es but a ſmall quantity of them; and as all theſe re very ſoluble in water, and as water has a ſtronger vith ſpirit of wine than it has with theſe matters, s ſpirit may be employed to ſeparate theſe matters from

from water. For this purpose we need only to add a good deal of the spirit of wine to the water, which keeps them dissolved: the spirit then seizes the water, and obliges the gummy, gelatinous, and saline parts which it contained in solution to separate from it. The reverse of all this passes in the separation of oily and resinous substances from spirit of wine by means of water. Spirit of wine coagulates the whites of eggs and animal lymph, by seizing upon the water which they contain.

The same may be said of the coagulum formed by mixing spirit of wine with concrete volatile alkali, dissolved by the smallest possible quantity of water. This coagulum, which is formed suddenly upon the mixture of these two liquors, and which is known in chemistry by the name *Offa Helmontii* is nothing else than a sudden crystallization of volatile alkali, occasioned by the addition of spirit of wine, which seizes the water in which that alkali was dissolved. The same may be said of the crystallization of all salts, which may be instantaneously effected by the means of spirit of wine. *See* CRYSTALLIZATION.

From what has been said concerning the dissolving power of spirit of wine, we may judge of its great utility in chemistry in extractions and separations. It is particularly very useful in the analysis of vegetables and animals by menstruums. By reflecting attentively on the properties of this solvent, many analyses and separations which tend to the progress and perfection of chemistry may be improved.

We shall finish this article with some reflexions on the nature of spirit of wine.

Stahl and most chemists believe, that spirit of wine is composed of a very attenuated and very light oil, intimately united by means of an acid with a larger quantity of water than that which enters as a principle in the combination of oil.

Juncker, on the contrary, appears to admit no other inflammable matter in spirit of wine than phlogiston united with the aqueous principle by means of an acid.

Lastly, Mr. Cartheuser positively advances, that spirit of wine is composed of pure phlogiston, not in an oily state, but immediately united with the watery principle alone.

This diversity of opinion amongst the ablest chemists proves, that the true principles of spirit of wine are not yet perfectly known. This proceeds from the difficulty of

oſing it without an intermediate ſubſtance, and
everal phenomena, ſome of which ſeem to ſhew,
not a true oil that enters as a principle into
ſition of ſpirit of wine, but phlogiſton alone;
rs ſeem to indicate the preſence of a true oil
the pureſt ſpirit of wine.

ix the beſt rectified ſpirit of wine with water,
allow it to evaporate ſlowly in open air, we ſhall
he ſurface of the water a certain quantity of oil;
ve ſeen above, that a true oil may be obtained
of wine by treating it with acids.

in, if we attend to the eſſential and fundamental
of ſpirit of wine, to its perfect miſcibility with
its flame, which is not accompanied with any
ke, to the impoſſibility of reducing it without
the ſtate of coal; laſtly, to this property,
it is inflamed we obtain nothing from it but a
ich burns, and pure water; all which properties
able to an oil properly ſo called; we muſt acknow-
not oil, but pure phlogiſton, is the inflammable
of ſpirit of wine. We have reaſon to believe,
oil which is ſeparated from ſpirit of wine by
xtraneous to it, and is only contained in ſpirit
because the means employed to purify this ſpirit
cient to deprive it of all oily matter; and alſo,
il obtained from mixtures of ſpirit of wine with
evidently an artificial oil, and produced in the
as we may ſee at the word ETHER.

it of wine contains a pure phlogiſton very much
and almoſt diſengaged, it acts upon the nervous
e all the ſubſtances which contain a very volatile
ttenuated inflammable principle. *See* WINE *and*
ON. It is alſo very powerfully antiſeptic: hence
ſucceſsfully employed to preſerve from putrefac-
ers ſuſceptible of it. It is uſed topically in gan-
nd alſo for the preſervation of dead animals, or
nimals. *(y)*

*See*

*Reaumur* diſcovered, that a mixture of ſpirit of wine
acquired a ſpecific gravity greater than would arith-
eſult from the proportions employed of each of theſe
Thus 50 meaſures of ſpirit of wine and 50 meaſures of
ed together, were found to make only 98 meaſures.
t progreſſion the denſity is encreaſed by mixing various

 pro-

*See for the rectification and purification of spirit of wine,* RECTIFICATION.

proportions of the two liquors, had not been determined till M. *Brisson* made a set of experiments with that view; an account of which is given in the Memoirs of the Academy of Sciences of Paris for the year 1769. From his experiments he has constructed the following Table, which shews this progression, and also enables us to discover the proportion of spirit of wine and water, in any given mixture of these (as brandies, rums, &c.) the specific gravity of which is found to correspond with any of the specific gravities in the Table. Thus, for instance, if we find upon accurate trial, that the specific gravity of the rum, brandy, or other mixture, whose strength is required to be known, be to that of water as $942\frac{1}{2}$ to 1000, we learn by inspection of the Table, that this spirituous mixture consists of equal parts of water and spirit of wine, of which spirit the strength is such, that its density is to that of the water as 837 to 1000. The 1st column shews the proportion of well rectified spirit of wine in the mixture; the 2d column shews the proportion of the water in the mixture; the 3d column shews the specific gravity of the mixture; the fourth column shews the difference between the specific gravity of the mixture and that of the preceding mixture; and the 5th column shews the proportion which the several augmentations of density, caused by penetration of the two liquors, have to each other, that is, their progression.

| Spirit of Wine. | Water. | Specific gravity. | Differences. | Proportional augmentations of density from penetration. |
|---|---|---|---|---|
| 16 parts | 0 parts | 837 | 0 | 0 |
| 15 —— | 1 —— | $852\frac{1}{2}$ | $15\frac{1}{2}$ | $4\frac{51}{125}$ |
| 14 —— | 2 —— | $867\frac{1}{3}$ | $14\frac{5}{6}$ | $8\frac{12}{125}$ |
| 13 —— | 3 —— | $881\frac{1}{3}$ | 14 | $11\frac{41}{125}$ |
| 12 —— | 4 —— | $894\frac{1}{2}$ | $13\frac{1}{6}$ | $13\frac{108}{125}$ |
| 11 —— | 5 —— | $907\frac{1}{3}$ | $12\frac{5}{6}$ | $15\frac{127}{125}$ |
| 10 —— | 6 —— | $919\frac{2}{3}$ | $12\frac{1}{3}$ | $17\frac{98}{125}$ |
| 9 —— | 7 —— | $931\frac{2}{3}$ | 12 | $19\frac{21}{125}$ |
| 8 —— | 8 —— | $942\frac{1}{6}$ | $10\frac{5}{6}$ | $19\frac{104}{125}$ |
| 7 —— | 9 —— | $951\frac{2}{3}$ | $9\frac{1}{6}$ | $18\frac{123}{125}$ |
| 6 —— | 10 —— | $959\frac{2}{3}$ | 8 | $17\frac{124}{125}$ |
| 5 —— | 11 —— | $967\frac{1}{4}$ | $7\frac{7}{12}$ | $15\frac{1}{125}$ |
| 4 —— | 12 —— | $973\frac{1}{3}$ | $5\frac{11}{12}$ | $11\frac{63}{125}$ |
| 3 —— | 13 —— | 979 | $5\frac{5}{6}$ | $7\frac{119}{125}$ |
| 2 —— | 14 —— | 985 | 6 | $4\frac{74}{125}$ |
| 1 —— | 15 —— | $991\frac{3}{4}$ | $6\frac{3}{4}$ | $1\frac{93}{125}$ |
| 0 —— | 16 —— | 1000 | $8\frac{1}{4}$ | 0 |

T *of* LIBAVIUS. *See* LIQUOR (SMOK-

T *of* NITRE. Spirit of nitre and nitrous
o names for the ſame thing. For its properties,
NITROUS). We ſhall here explain the manner
g it, or of decompoſing nitre in order to obtain

acid, and ſeveral matters containing it, are
e ſubſtances employed for the ſeparation of
d from the fixed alkali with which it is united
ecauſe, in general, the former of theſe two acids
than the latter. In ſeveral ways nitrous acid
ained by diſtillation; which, however, are funda-
he ſame, although they vary in ſome circum-
cording to the nature of the intermediate ſub-
loyed, and the required ſtrength of the nitrous

oſt frequent method of diſtilling ſpirit of nitre,
n great works, is to employ clay as an interme-
ance. As this kind of earth contains vitriolic
very proper for decompoſing nitre.
rts of dry and powdered clay are to be well mixed
part of nitre. This mixture is to be put into an
are retort, placed in a reverberatory furnace.
etort a receiver is to be fitted, which is to be well
the diſtillation is to be promoted by a gradual
is very gentle at firſt, and raiſed towards the end
hat the retort ſhall be very red-hot.
ſtillers of aqua-fortis uſe very few precautions,
dingly their ſpirit is generally weak and impure.
e firſt place, they employ nitre of the firſt, or at
e ſecond boiling, which contains always much
ſalt. Hence the acid which they obtain is mixed
nſiderable quantity of ſpirit of common ſalt. It
ently a kind of aqua-regia.
ſecond place they do not dry well their clay, by
ans their acid is weak; although they always keep
moſt watery part which paſſes firſt; this they call
*ting it.*
the lute which they uſe for joining their veſſels
rth formed into a paſte with water, a part of which
the receiver, eſpecially when they unlute the
nd renders the ſpirit of nitre turbid. But as almoſt
qua-fortis which they make is for purpoſes in which
accuracy is not required as in chemical opera-

 tions,

[illegible] nar fom

[illegible] Two m

[illegible] equal propo

[illegible] adhere

[illegible] balloon, i

[illegible] filled with a fi

[illegible] dish soaked wit

[illegible] fixed in air, and forme

[illegible] eggs. The whole lutin

[illegible] Then the diftilla

[illegible] fire. The bal

[illegible] which are condenfe

[illegible] of fpirit of nitre diftill

[illegible] drops. [illegible] diftillation is to be continue

[illegible] the retort is red-hot, and no more vapor is raifed.

Whe

e veſſels are cooled, they are cautiouſly to be
d the liquor in the balloon is to be quickly
a clean and dry glaſs bottle, through a glaſs
ich bottle ought to be quickly ſtopped with a
e. This is the method of diſtilling ſmoking
re uſed by Mr. Beaumé; and it is a very good
ſmall earthen diſh filled with ſand, on which
of the retort reſts, is very uſeful to prevent the
and too unequal application of heat, which
it certainly liable to be broken. The fat lute
linſeed oil is not capable of being injured by
ſtops very cloſely. But as it remains always
ires to be held by the linen ſoaked in lute of lime
of eggs.

ors of this ſmoking ſpirit of nitre are very elaſtic,
ly condenſible; for which reaſon the diſtillation
owly conducted, and muſt be avoided in hot
A brick wall muſt be interpoſed betwixt the
the balloon to prevent this veſſel from being
heated; the balloon muſt be covered with wet
uently renewed, and even the ſmall hole of the
ſt be ſometimes unſtopped to give vent to the too
too copious vapors; otherwiſe the whole appa-
d burſt with exploſion.

ve perceive that the drops ſucceed each other
d that by unſtopping the ſmall hole, red vapors
e length of a foot or more with a hiſſing noiſe;
n that the veſſels are ready to burſt. The heat
be leſſened, and the ſmall hole muſt be very
unſtopped, till the diſtillation be much mo-

when we pour the nitrous acid into the bottle,
be very careful not to ſtand in the way of a cur-
r, becauſe the vapors are very corroſive and
For the ſame reaſon alſo, the mouth of the
ght to be ſtopped as ſoon as the liquor is poured
for the fumes continue in it more than twelve

T (GLAUBER's SMOKING) *of* NI-
Glauber was the firſt chemiſt who thought of
itrous and marine acids by means of pure vitrio-
By this method we may obtain a nitrous acid
centrated; and the proceſs is more eaſy, quick,
ient than the preceding. This diſtillation ought
e in the following manner.

[illegible]

[illegible]

[illegible]

ry the colors of ſandy parterres. It is called the *iſtillers of aqua-fortis.*

iduum of the diſtillation by vitriol contains vitrio-
ar, mixed with a pretty large quantity of the
rth of this vitriol. Vitriolated tartar may be
obtained from it by lotion with water, which is
to be filtrated, evaporated, and cryſtalliſed. A
nartial earth remains, which is called *colcothar*,
*arth of vitriol*, after it has been ſufficiently waſhed.
y remark upon this ſubject, that as the nitrous
engaged from its baſis by the acid of vitriol, it
urally to be applied to the martial earth of this
ut as the nitrous acid adheres but weakly to iron,
when this metal is calcined and deprived of its
, as it is in this operation, the heat that is em-
nore than ſufficient to diſengage it, and to make
irely in diſtillation.

the reſiduum of the diſtillation of ſpirit of nitre
r's manner, when no iron is mixed with it, forms
te and very pure vitriolated tartar, which may be
filtrated, evaporated, and cryſtalliſed.

ſe reſiduums generally contain alſo a little nitre,
having been ſufficiently in contact with vitriolic
eſcaped its action, and is not decompoſed.

T (DULCIFIED) *of* NITRE. Dul-
t of nitre is a mixture of one part of nitrous acid
parts of rectified ſpirit of wine, digeſted to-
*z)*

ous acid acts powerfully on ſpirit of wine, it is
conſiderably milder by this mixture. It is uſed
cinally, and is conſidered as aperitive, and power-
etic. It is added by drops to potions and juleps,
given an agreeable acidity.

TUS RECTOR. The *ſpiritus rector* is a
uated, very ſubtle principle, in which the ſmell
riferous bodies peculiarly reſides.

ain the ſpiritus rector from odoriferous ſubſtances,
ers are to be diſtilled in the cucurbit or body of
c placed in a water-bath, with a very gentle heat,
om thirty to thirty-five degrees of Mr. Reaumur's

London and Edinburgh Diſpenſatories direct that the
ould be diſtilled. This operation ought to be perform-
very ſlow, and gradually raiſed fire, that exploſions
vented.

thermometer, till we perceive that what rises in distillation has little or no smell.

The principle of smell in bodies is in general too subtle and too fugacious to be obtained alone and pure, by any method whatever. Accordingly, it rises by means of the water contained in substances distilled in order to procure it, and is dissipated and overwhelmed in water. If the odoriferous matters from which the spiritus rector is required to be procured, were absolutely dry, and contained no other volatile principles, a little water or spirit of wine ought necessarily to be added, to furnish a kind of basis to this spirit, which would otherwise be dissipated and evaporated, so that it could not be collected.

This principle of the smell of bodies is miscible with water, with spirit of wine, and with oils. It seems however to be of different natures, according to the substances which furnish it. Its properties shew that it is in general composed of an inflammable principle, and of a saline substance, both extremely attenuated. But the spiritus rector of some substances appears to be more of a saline, and that of others more of an oily nature.

All matters, the smell of which is quick, pungent, and which do not affect the brain and nervous system, as the acrid, cruciform plants, and substances which undergo the acid fermentation, contain a spiritus rector probably more saline than oily.

Those, on the contrary, whose smell is sweet, nauseous, or strong, without acrimony or pungency, and which affect the head, by curing or occasioning hysterical or convulsive accidents; such are ambergrise, musk, castor, burnt coffee, opium, narcotic plants, camphor, all aromatic plants, and lastly, the substances which undergo the spirituous fermentation; have, according to all appearance, a spiritus rector which partakes of the nature of oil. For besides that the effects produced by these substances are similar to those of the vapor of charcoal, the spiritus rector of some of them is really inflammable; as, for instance, that of fraxinella, the exhalations from which form an atmosphere that may be inflamed with a lighted taper.

The spiritus rector of all aromatic plants seems particularly to be associated with their essential oils; at least, all these oils contain a good deal of it. To this principle they certainly owe their smell, and probably their volatility and thinness; for those which from age, or from not having been preserved in well-closed vessels, have lost their proper

smell,

: at the ſame time much leſs thin and volatile, y are no longer capable of being raiſed by the oiling water; and beſides, the plants from which us rector has been obtained, furniſh little or no il. *See* OILS (ESSENTIAL).

iritus rector, even that of aromatic plants, altho' an oily nature, is perfectly miſcible with water; n only proceed from its great tenuity, or from principle which enters its compoſition.

IT *of* SALT. The ſpirit of ſalt, or acid of ſalt, can only be obtained by means of a ſuffi- owerful intermediate ſubſtance, to diſengage it native fixed alkali, which is the baſis of com- . Vitriolic acid is the moſt proper and moſt termediate ſubſtance for the diſtillation of ſpirit It is employed, either engaged in a baſis with has leſs affinity than with that of common ſalt; n order to obtain Glauber's ſmoking ſpirit of ſalt. ry ſpirit of ſalt is diſtilled by the mixture of one ommon ſalt with two parts of dried clay, pre- the ſame manner as we have deſcribed for the n of ſpirit of nitre. *See* SPIRIT *of* NITRE. The ſalt obtained by this method is white and not although it may be conſiderably ſtrong, if the lay have been previouſly well dried.

ay obſerve, that a ſmoking ſpirit of ſalt cannot be by means of martial vitriol, calcined till it becomes s practiſed for the ſpirit of nitre. I have tried this diſtillation; and although a very violent heat ed, yet very little marine acid was procured. The on of this difference is, that marine acid diſſolves, ore eaſily than nitrous acid, metallic earths de- their phlogiſton, and adheres to them much more Hence, as ſoon as the marine acid is diſen- om its baſis by the acid of vitriol, it applies itſelf artial earth of this vitriol, which retains it with re ſtrength than it is capable of retaining nitrous

IT (GLAUBER's SMOKING) *of* SALT. the ſtrongeſt and moſt ſmoking ſpirit of ſalt, we ed to employ as an intermediate the pure vitriolic Glauber has practiſed. But this operation, eſpe- en we would have ſpirit of ſalt highly concen- very difficult and laborious, becauſe the vapors h more difficultly condenſible than any others. The

The following is the process successfully practised by Mr. Beaumé.

Common salt is put into a tubulated stone-ware or glass retort, which is to be placed in a furnace for distilling; and to this retort a balloon is to be fitted, exactly in the same manner as for the distillation of smoking spirit of nitre. *See* SMOKING SPIRIT *of* NITRE. This apparatus is to be left till the lute has become firm; then through the tubulated opening of the retort, by means of a glass funnel, a quantity of rectified vitriolic acid previously diluted with a little water, equal to a third part of the weight of the salt, is to be poured at several different times, and the opening is to be closed each time immediately after a part of the acid has been added.

As soon as the vitriolic acid is added, we see white vapors passing from the retort into the receiver. These are the smoking spirit of salt which this acid disengages, even without fire; for which reason these first vapors ought to be allowed to pass, before the fire be kindled; which ought not to be done till they are considerably diminished, otherwise the distillation would go on too fast at first, and the vessels might be broken.

A very little fire is to be kept up in the furnace, and only as much as is necessary to continue the distillation. Lastly, the distillation is to be conducted to the end with the same attentions which we directed for smoking spirit of nitre; and when it is finished, the spirit of salt is to be collected in the same manner.

Betwixt this process and that by which a smoking spirit of nitre is obtained in Glauber's manner, two essential differences may be perceived. The first is, that in this distillation the vitriolic acid is not added till the vessels are arranged and luted; and hence a tubulated retort is necessary. The reason of this is, that vitriolic acid disengages the acid of common salt without heat, and as soon as it touches this salt; and that the vapors which pass out copiously from the retort, by keeping the neck constantly wet, render the application of the lute impossible. When the lute happens during the distillation to be deranged, it cannot be again repaired. The shortest method then is to discontinue the operation, and begin again.

The second difference betwixt the distillation of smoking spirit of nitre and smoking spirit of salt by means of vitriolic acid, is, that water is added in the latter distillation, and not in the former. The reason of this is, that the vapors of

ntrated marine acid are ſo much more diſſi-
ndenſible than thoſe of nitrous acid equally con-
, that if well concentrated vitriolic acid, and
ted common ſalt be employed, almoſt all the
cid would be diſſipated in vapors which would be
ſcarcely a ſenſible quantity of liquor would be
. *See* ACID (MARINE) *for the properties of ſpirit*
*nd* SALT (COMMON).

eſiduums of the diſtillations of ſpirit of ſalt contain
's ſalt. In that of the diſtillation by means of clay,
is confounded with much earth, and difficultly
le. But the reſiduum of the diſtillation by vitriolic
pure Glauber's ſalt. This ſalt appears a white
aſs at the bottom of the retort. It ought to be
in a crucible, that any remaining acid may be
. It is then to be treated by ſolution, filtration,
tallization.

is diſtillation, Glauber firſt diſcovered the ſalt
e afterwards examined, and called *ſal mirabile.*
me is ſtill continued; ſo that it is now called *ſal*
*ſal mirabile Glauberi*, or *Glauber's ſalt*. *See* SALT
UBER.

RIT (DULCIFIED) *of* SALT. Dulcified
ſalt is made by mixing this acid with twice its
f rectified ſpirit of wine, and digeſting this mixture
month.

is acid has much leſs diſpoſition than the vitriolic
ous acids to combine with inflammable matters,
t be ſo well dulcified as they can by ſpirit of

rs differ much concerning the methods of dulcifi-
The proportions are from two to five or ſix parts of
wine to one part of ſpirit of ſalt. Some authors do not
ether the ſpirit of ſalt ought to be concentrated and
, or not; others require that a ſmoking ſpirit
e employed. Laſtly, ſome direct the diſtillation of
ture, and others are contented with a ſimple di-
But in whatever manner the operation is per-
the acid remains crude, and not much dulcified:
ulcified ſpirit of ſalt is not uſed in medicine; for
es do not eſſentially differ from thoſe of dulcified
nitre, which is infinitely milder.

ne acid, although very concentrated and very ſmok-
es not produce, when mixed with ſpirit of wine,
ry inconſiderable heat and effervescence, and much
inferior

inferior to those occasioned by vitriolic acid, and still more by nitrous acid; which difference proceeds from the little action marine acid has upon the principles of spirit of wine.

These two substances are but little altered by being mixed together: for Mr. Pott having combined a dulcified spirit of salt with an alkali, obtained a *regenerated sea-salt*, which decrepitated upon hot coals, and precipitated lead and silver from their solutions in nitrous acid into corneous metals. Nevertheless, we are certain that a part of the marine acid contracts an union, and even an intimate union, with spirit of wine: for Mr. Pott relates, that having distilled to dryness the thick matter remaining after the most fluid and volatile part of the mixture had been separated, he found a black, residuous coal, which cannot be obtained by distilling any of these two matters separately. *See* ETHER (MARINE).

SPIRIT *of* SULPHUR. Spirit of sulphur is nothing else than vitriolic acid obtained from sulphur by burning.

As sulphur cannot furnish its acid but by burning, and as it cannot burn but in open vessels and free air, we can therefore obtain but a small quantity of acid by this method.

Before the acid of sulphur was known to be the same as ordinary vitriolic acid, a spirit of sulphur was prepared with great expence and trouble, upon the supposition that it had peculiar properties. For this purpose, sulphur was burnt in an open crucible, placed upon a stand in an earthen dish filled with hot water. A large capital or glass-bell was suspended above this dish. The acid of the burning sulphur meeting the vapor of the hot water, united with this water, and fell down along the sides of the bell, or by the beak of the capital. By this method a very weak acid was procured, which was afterwards concentrated: but at present this operation is only performed to shew, that the acid contained in sulphur is not decomposed during combustion, and that it is only one and the same thing with vitriolic acid.

The true method of obtaining much acid of sulphur, is to burn it in close vessels by means of a small quantity of nitre, as it seems to be practised in some places. *See* CLYSSUS. *(a)*

SPIRIT

*(a)* The greatest part of the vitriolic acid now employed is obtained by burning sulphur. The vapors of burning sulphur are

IT *of* VENUS. This name is given by to the acid of vinegar highly concentrated, ob- distilling verdegrise, or crystals of verdegrise, or s, which are nothing else than combinations of ith acetous acid.

peration by which spirit of Venus is obtained is . Nothing more is required than to put verde- crystals of verdegrise into a retort, one third part ought to remain empty, as is usual: to this retort r is to be adjusted, and the distillation begun with ntle fire: the first portions of liquor which pass e set apart, as they are nothing but phlegm: the n is to be promoted, by gradually augmenting the the retort begins to be red-hot, and nothing om it.

latile, vitriolic, or sulphureous acid. These are very condensible. For which reason, very large vessels and e are required in this operation. In great works, ssels are used, called *houses*, of a prismatic form, of e altitude is about ten feet, and the base, which is a is six feet long and four feet broad. The bottom of ese vessels is covered with a little water to assist the con- of the vapor. Above the water is placed a small vessel f containing a few pounds of sulphur, to which a small nitre is added; because, by this addition, a larger quan- lphur may be burnt without access of fresh air. The to be filled with the vapor of hot water, and their sides ith the condensed steam: then the sulphur is to be y touching it with a red-hot iron: the vapor of the ulphur rises slowly; and when it has risen as high as of the great vessel, this must be stopt, or very nearly t the vapor may be confined. The sulphur continues ill the air contained within the vessel and the nitre be capable of maintaining the combustion. The vapor considerable time before it be entirely condensed, not- ing that this condensation is facilitated by the water in , and especially by the steam of water with which the previously filled. When all the vapor of the sulphu- is at last condensed, the sulphur is to be again kindled, added if it be necessary, and the process repeated as be- hen a sufficient quantity of acid is collected, it is to be of the vessel; and after it has lost its *sulphureous* or vo- lity by exposure to air, it is concentrated and rectified tion. *See* ACID (VITRIOLIC) ACID VOLATILE SUL- s, *and* CONCENTRATION *of* VITRIOLIC ACID.

The

The acid of vinegar passes in this distillation partly in white clouds, and partly in drops. This acid is very strong; because in general acids, which are combined with any body whatever, are by that means deprived of all their superabundant water. Besides, as the acid of vinegar is fixed and retained in a certain degree by copper, it may be easily dephlegmated in the beginning of the distillation.

The spirit of Venus has a very vivid, pungent smell; almost as suffocating as volatile sulphureous acid. The Count de Lauraguais discovered, that if this acid be heated in a wide-mouthed pan, and fire applied to it, it will burn entirely like spirit of wine; and leave no residuum. This experiment, added to the observations made by Beccher and Stahl upon the production of vinegar, shew, that spirit of wine enters as a constituent part into the composition of this acid. The Count de Lauraguais also observed, that spirit of Venus well concentrated, easily crystallizes without addition; and this observation has been since confirmed by the Marquis de Courtanvaux. *See* FERMENTATION (ACID), *and* VINEGAR.

As the last portions of the acid of vinegar adhere pretty strongly to the copper in the verdigrise, and to the crystals of Venus; and as we are obliged to give a strong degree of heat to expel them, they then raise along with them a small quantity of this metal, which gives a greenish color to the spirit of Venus: but it is easily freed from these cupreous parts by a second distillation with a very gentle heat; and then it becomes very white.

The acid of vinegar, thus concentrated, has many other properties worthy of attention; amongst others, those of forming ether when distilled with spirit of wine. *See* ETHER (ACETOUS), *and* VINEGAR (RADICAL).

We must observe, that when verdegrise is employed for the preparation of spirit of Venus, we obtain very little of this spirit, and that it is more oily than when it is obtained from crystals of verdegrise, which furnish nearly one half of their weight of the spirit.

After this distillation, we find in the retort the copper which had been the basis of the crystals of verdegrise. This copper is divided into very small parts, which, however, are agglutinated into lumps that are very friable. Its color is blackish, which proceeds from a covering of coal that it has received from the oily matter of the vinegar, which is decomposed towards the end of the distillation. Mr. Beaumé observes, that this coal is easily kindled by the

ation of fire, and burns, like tinder, upon the
the copper.

pper, not having loſt any of its phlogiſton, may
uſed into an ingot of red copper. We ought only
ttle black flux, to prevent or repair the calcina-
n may be made during its fuſion.

T *of* WINE. *See* SPIRIT (ARDENT).

T *of* VINEGAR. *See* VINEGAR (DISTIL-

T *of* VITRIOL. This name is given to the
ns of phlegmatic vitriolic acid which paſs in the
of vitriol, or in the concentration of vitriolic
e name is given in general to every dilute vitrio-

IT (VOLATILE) *of* SAL AMMONIAC.
tile ſpirit of ſal ammoniac is the volatile alkali
baſis of ſal ammoniac, and that has been diſen-
means of ſome intermediate ſubſtance, which alſo
from it ſome of its oily principle, by means of
was capable of a ſolid or concrete ſtate; hence
is always liquid.

termediate ſubſtances which have the property of
; this alteration upon volatile alkali are ſtony and
alxes. If two parts of quicklime ſlaked in the
minium, be mixed together with one part of ſal
, and if this mixture be diſtilled, a fluor volatile
l be obtained in form of a very quick and pene-
irit.

hloſſer, in his Diſſertation on the Fuſible Salt of
ys, that the volatile alkali which ſerves as a baſis to
horic acid in this ſalt is always fluor, whether it be
d by fire alone, or by any intermediate ſubſtance;
concrete volatile alkali combined with this acid
afterwards be obtained but in a fluor ſtate; which
at the phoſphoric acid has the property of taking
tile alkali the matter by means of which it is cry-
. *See for the properties of volatile ſpirit of ſal am-*
LKALI (VOLATILE), *and* AMMONIAC (SAL).

ATITES. *(b)*

STEEL.

EATITES, *Lapis Ollaris*, or *Soap-rock*, is a mineral ſub-
a conſiſtence intermediate between ſtones and earths.
of its properties it reſembles clays. It is ſoft to the
y be formed into a paſte with water, ſufficiently ductile
to

STEEL. Steel, considered chemically, is nothing else than iron reduced by art to a particular state, which occasions some changes in its properties; but these properties are essentially the same as those of iron; that is, iron and steel are not two different metals, but the same metal in two different states: therefore all the fundamental properties of steel are mentioned under the article IRON. We shall here only describe the method of making steel, explain the theory of that operation, and mention its differences from those of iron.

Stahl, Cramer, and all good chemists, justly consider steel as an improved iron, which is possessed of a larger quantity of inflammable principle, so necessary to all metals, and which really contains fewer heterogeneous, and more metallic, parts than an equal bulk of iron. We shall be convinced of this truth by a description and explanation of the methods of converting iron into steel, and by examining the characteristic properties of steel.

Steel may be made by fusion or by cementation. The first method is used to convert iron into steel immediately from the ore. All ores of iron are not used indifferently for this purpose; because some of these, which are therefore called *ores of steel*, are much fitter than others to furnish good steel; and the steel extracted from them is called *natural steel*. (c)

The

to be worked on the potter's wheel; and by fire it is hardened so as to strike fire with steel. It also has the property of fuller's earth, in cleansing cloaths from grease. But it does not diffuse in water so well as clays do. And when digested with vitriolic acid, it does not form alum, as clays do, but a salt similar to Epsom salt, hence it contains a large portion of the earth called Magnesia, as M. Margraaf has discovered. *See* MAGNESIA. This substance is so soft as to be cut with a knife, or with a tool turned by a lathe. Accordingly it is, in some places, made into pots for the use of the kitchen, and hence is named *Lapis ollaris*. The *Serpentine stone*, the *nephritic stone*, the substances called *French chalk*, and *Spanish chalk*, are so many kinds of Steatites. *See* SERPENTINE STONE.

(c) Steel is made sometimes directly from the ore, but more frequently from crude or cast-iron. These methods of making steel are not known in England, but are practised in Sweden and other parts of Europe. The process for making steel from cast-iron is thus described by Swedenborgius, as it is performed in Dalecarlia.

The

ner method of making ſteel conſiſts in chuſing the
d iron, or that which is moſt malleable, whether
r cold; and impregnating this iron with a larger

from which the crude iron to be converted into ſteel
is of a good kind. It is black, friable, and compoſed
nall grains; and it produces very tough iron. The
into ſteel is made upon a forge-hearth, ſomething
n common. The ſides and bottom are made of caſt-
tuyere is placed, with very little inclination, on one
plates. The breadth of the fire-place is 14 inches;
greater. The lower part of the tuyere is 6 ½ inches
ottom. In the interior part of the fire-place, there is
opening for the flowing of the ſuperfluous ſcoria.
hen firſt put ſcoria on the bottom, then charcoal and
charcoal, and upon theſe the caſt-iron run or cut into
. They cover the iron with more charcoal, and excite
When the pieces of iron are of a red-white, and before
to melt, they ſtop the bellows, and carry the maſs
ge hammer, where they break it into pieces of three
nds each. The pieces are again brought to the hearth,
ithin reach of the workman, who plunges ſome of
he fire, and covers them with coal. The bellows are
w ſlowly till the iron is liquefied. Then the fire is
and when the fuſion has been long enough continued,
are allowed to flow out; and at that time the iron,
The workman adds more of the pieces of crude iron,
treats in the ſame manner, and ſo on a third and a
, till he obtains a maſs of ſteel of about a hundred
hich is generally done in about four hours. This maſs
d carried to the hammer, where it is forged, and cut
eces, which are further beat into ſquare bars four or
ng. When the ſteel is thus forged, it is thrown into
it may be eaſily broken; for it is yet crude and coarſe-
The ſteel is now carried to another hearth ſimilar to
and there broken in pieces. Theſe pieces are laid
n the fire-place, firſt two parallel, upon which ſeven
hers are placed acroſs, then a third row acroſs the ſe-
ch a manner that there is ſpace left between thoſe of
w. The whole is then covered with charcoal, and the
ed. In about half or three quarters of an hour the
made hot enough, and are then taken from the fire,
to the hammer, to be forged into little bars from half
o feet long, and while hot, are thrown into water to
l. Of theſe pieces 16 or 20 are put together ſo as to
dle, which is heated and welded, and afterwards forg-
four inches thick, which are then broken into pieces
nt length for uſe.

portion of inflammable principle, by cementation alone, without fusion.

To understand well these methods of making steel, we must attend to two essential properties of iron. The first is, that of all metals it is the most difficultly fusible; and that therefore although in the smelting of its ores its fusion be much assisted by the sulphureous parts of the ore itself, yet, as these parts are always expelled as much as is possible, iron never enters into so thin and perfect a fusion as the other metals.

The second property of iron to which we ought to attend is, that the earth of this metal is capable of combining with the inflammable principle, and of being metallised without fusion.

These things being premised, it happens, in consequence of the former property, that, in the first fusion of ores of iron, we obtain only a hard and brittle iron, both from the sulphureous parts from which this iron is not entirely disengaged, and from the presence of a greater or less quantity of earthy matters, which are either unmetallic; or which, if they be ferruginous, have not been metallised from want of immediate contact with the phlogiston of the fuel.

We may easily perceive that these earthy parts, unmetallic or not metallised, cannot be entirely separated from the perfect iron, because the fusion is not sufficiently thin for that purpose: but in proportion as the iron is deprived of sulphur, its fusion becomes more and more difficult, and we are obliged to have recourse to another expedient than fusion to disengage it from its earthy parts, which in the first smelting remain intercepted betwixt the metallic parts. This expedient is the forge. The impure iron intended to be rendered malleable is to be heated red-hot, and struck by a very heavy hammer.

This percussion, that iron softened by heat sustains, presses strongly, and solders or welds together the metallic parts, which alone are capable of uniting together; and obliges the unmetallic parts, which are incapable of uniting with the metal, to separate. By this operation these unmetallic parts are pressed between the parts of the iron, and driven by degrees to the surface of the metal, from which they are detached in form of dust and scales. This treatment, which is a kind of kneading of the iron, is to be repeated till it has acquired the proper degree of purity and ductility.

The

rations by which ſteel is to be extracted from its entially the ſame as theſe employed for iron; but from them in being much more exact; that an urer, more filled with phlogiſton, and better diſ- om its earthy parts, may be obtained.

eed in this intention, much ſmaller quantities uſed at once than when iron is to be extracted re. Pieces of the firſt fuſion are to be put into lled and covered with charcoal, and expoſed to a t excited by ſtrong bellows. Theſe pieces are fuſed, and kept in fuſion a longer or ſhorter rding to the nature of the ore; after which they forged, as iron is, but always in much ſmaller till they are become perfectly ductile both when hen cold. Nothing then remains but to temper f which we ſhall preſently ſpeak.

operations, which are to be ſeveral times repeat- n that is changed into ſteel muſt evidently be r purified, and furniſhed with a much greater inflammable principle, than in the ſmeltings s of large quantities of iron. As the maſſes of nall in theſe operations for the procuring of ſteel, are ſurrounded with a much larger proportion , the fuſion is not only more complete, by which on of the earthy unmetallic parts is much pro- alſo a greater number of ferruginous parts are liſed; and as all theſe parts of iron are in more ntact with the charcoal, which is capable of ſup- m with inflammable principle, they receive the ntity of this principle, with which they can

e obſervation may be applied to the operation of practiſed upon ſmaller maſſes: for the heteroge- are much more eaſily and copiouſly preſſed out aſſes than great.

act purification of iron, by which it is converted muſt evidently be attended with conſiderable loſs, ion, from the ſeparation of all its heterogeneous his diminution amounts to nearly one half of the the iron. This great loſs does not proceed alto- n the ſeparation of heterogeneous parts; for in rations uſed for this ſeparation, ſome part of the lways deſtroyed and burnt, although all poſſible s are taken to diminiſh this inconvenience, by

ſecuring the melted or red-hot metal from the contact of external air as much as is poſſible.

*Artificial ſteel* is made without fuſion from iron ready forged. The chief point to be attended to in the making of the beſt artificial ſteel, is to chuſe the iron which is moſt perfect and moſt malleable, either when it is hot or cold which quality always ſhews that the iron is well purified. It is firſt to be forged into plates or bars, rather ſmall than large, according to the works for which it is intended; and it is then to be cemented with matters capable of giving to it much inflammable principle. The matters which compoſe this cement vary according to the uſes of different manufactures. They are all good, provided they contain no ſulphur, or vitriolic acid, which might form ſulphur during the operation; becauſe ſulphur, having much affinity with iron, would certainly unite with this metal, would entirely or partly fuſe it, and would, by reducing it to a mineral or pyritous ſtate, give to it qualities very different from thoſe which good ſteel ought to have.

The matters which enter into the compoſition of the cement for ſteel, are the coals of animal or vegetable ſubſtances mixed with aſhes, calcined bones, and other matters of this kind. Mr. Cramer propoſes theſe two following receipts of cements for ſteel, which appear to be very good.

Take one part of powder of charcoal, half a part of wood-aſhes, and mix them very well together: or,

Take two parts of charcoal, moderately pulveriſed; one part of bones, horns, hair or ſkins of animals, burnt in cloſe veſſels to blackneſs, and powdered; half a part of wood-aſhes, and mix them well together.

When ſteel is to be made, the bars of iron are to be placed vertically in a cylindrical crucible, which ought to be three inches higher than the bars, and into which a ſtratum of the cement of about the thickneſs of a finger has been previouſly put and preſſed down. The bars ought to be about an inch diſtant from each other, and from the ſides of the crucible. The interſtices and crucible are then to be filled with cement, ſo that the bars ſhall be covered with about the thickneſs of two inches at leaſt. The crucible, previouſly covered with a lid which fits it exactly, and which muſt be carefully luted with clay mixed with ſand, is to be placed in a furnace where an equal fire is to be kept; ſo that the crucible ſhall be red-hot during eight or ten hour : the iron will then be found to be converted

into

which will be so much better as the iron em-
of a better quality: it then only requires to be
We may observe, that in this operation the
no diminution of weight, and no scoria appear
rface, as Mr. Cramer remarks. By the sole
erefore, of a new quantity of phlogiston, the
s the quality of steel. Thus, if this iron con-
parts of martial earth which was not metallised,
entation they are metallised, and the iron or
reby improved: but if the iron contained some
tallic parts, they are not separated by this ope-
use the metal has not been fused: and as the
iron which is usually sold, is never so well
m these extraneous matters, as that which is
to steel in the great works for procuring steel
of iron; hence, in general, artificial steel made
ion is not so perfect as that made by fusion.
observe that, in the cementation above de-
iron combines with a part of the phlogiston of
without fusion; which effect proceeds from a
perty of the earth of iron, by which it is capable
g with the inflammable principle, and of being
thout fusion, which is, nevertheless, necessary
tion of all other metallic earths.
which has received only the above-mentioned
differs from iron in its color, which is more
own; in its grain, which is finer and closer;
a greater ductility, flexibility, and softness:
t difference of steel from iron, which renders
able for many purposes and arts, is the extreme
quires by being tempered.
ation is very simple. It consists in making
, and then in plunging it suddenly in cold
an instant all the qualities of this steel are
his tempering; so that from being very ductile
ecomes so hard and so stiff, that it is no longer
eing cut by the file, but is itself capable of
ercing very hard bodies; that it does not yield
er, but may be sooner broken in pieces like
be extended. It is sonorous, brittle, very
capable of acquiring the most lively and
l polish, as we see in finely wrought toys of

f this metal is very extensive for numberless
nd necessary utensils of all sorts, of which

without it we ſhould abſolutely be deprived: but what renders its uſe ſtill more general is, that we can diverſify at pleaſure its hardneſs and ductility, by varying the temper. The hotter the ſteel is when tempered, and the colder the water into which it is plunged, the greater hardneſs it acquires; but, at the ſame time, it becomes ſo much more brittle. This very hard temper is neceſſary for certain tools deſigned to cut very hard bodies. On the contrary, the leſs hot the ſteel is when tempered, and the hotter the water is in which it is tempered, the leſs hard it becomes, and alſo the greater ductility it retains; and hence many tools may be made of it fit for cutting bodies moderately hard, which tools are leſs liable to have their points broken, or their edges notched, than if they were made of a harder ſteel.

No other general rule can be given for the tempering of ſteel than that we have mentioned. The proper degree of heat is always relative to the uſe to which the tools to be made of this ſteel are to be applied.

Another very convenient property of ſteel is, that after it has been tempered, it may be again untempered and ſoftened to any degree that we think proper. For which purpoſe we have only to heat it more or leſs, and to let it cool ſlowly. By this method we may ſoften the hardeſt-tempered ſteel.

As the temper is a very eſſential point with regard to ſteel, and that the beſt is in general that which gives the greateſt hardneſs, and deſtroys the leaſt of the ductility of the metal, various ſubſtances are uſed, into which ſteel to be tempered is plunged. Such are ſuet, oil, urine, water impregnated with ſoot, with ſal ammoniac, or with other ſalts. Theſe particular methods are the baſes of many ſecrets in different manufactures; their advantages cannot be aſcertained without a very accurate and continued examination. Very intereſting reſearches remain to be made on this ſubject.

Steel is uſually ſold tempered, becauſe, in many manufactures of it, the cuſtom is to temper it as ſoon as it is made, probably that the purchaſers of it may be the better able to judge of its quality. When this ſteel is to be uſed, it muſt be untempered, that it may be extended, filed, and receive the form intended to be given to it; after which each workman tempers it again in his manner. But we alſo find amongſt merchants Engliſh ſteel in ſmall bars, which is not tempered, and which is very good,

Well

Well polifhed plates of fteel, put on a gentle fire of charcoal, acquire different colors on their furface, and pafs fucceffively through feveral fhades, as they become hotter, in the following order; white, yellow, orange, purple, violet, and laftly, blue, which difappears and leaves a water-color, if the fteel has been heated too much or too long. Thefe different fhades mark the degree of heat or of annealing applied to different tools or utenfils. The moft generally ufed fhade is the blue, fuch as that given to fteel fprings.

One of the moft important properties of fteel is the magnetic quality which it is capable of acquiring much better than iron. Good mariners compaffes cannot be made without needles of fteel.

From what we have faid, we may judge that fteel is much better purified iron than any other iron, impregnated with a larger quantity of inflammable principle, and hardened by the temper. Some celebrated natural philofophers, but who were not chemifts, have advanced, that fteel was only iron which ftill retained fomething of its mineral nature, and that its ftate was intermediate betwixt that of caft-iron and foft forged iron. But this opinion is manifeftly erroneous. They have been deceived by the hardnefs and brittlenefs of caft-iron, which are nearly as great as in fteel. But thefe qualities proceed from a remaining part of the mineralifing fubftances, which leave it a pyritous character, very different from that of true fteel, fince this can only be hardened by the temper, and fince in the preparation of it all fulphureous matter muft be carefully avoided. The miftake of thefe authors proceeded from their ignorance of the inflammable principle, the properties of which have been fo well explained by the illuftrious Stahl, and from their being led into an error by the old chemifts, who perpetually confounded phlogifton, or the pureft and fimpleft inflammable principle of all bodies, with fulphur, with fulphureous matters, and with moft other inflammable compounds.

Steel may be unmade, or reduced to the ftate of iron, by a management fimilar to that by which it is made, that is, by cementation. But the cement ufed for this purpofe muft be compofed of fubftances entirely free from inflammable matter, and rather capable of abforbing it, as calcareous earth and quicklime are. By a cementation then with thefe matters, continued during eight or ten hours, fteel is reduced to the ftate of iron.

Stahl considers it as an undecided question, whether steel be more fusible than iron, and says, that the workmen cannot decide it from the violence of fire necessary to melt either of them. He believed with reason, that this question might be decided by melting these metals in the focus of a burning speculum. Mr. Macquer says, that by this method he found steel much more fusible than iron *(d)*. This greater fusibility of steel can be only attributed to the greater quantity of phlogiston united with it, as phlogiston is in general the cause of the fusibility of metals. *(e)*

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*(d)* Soft forged iron can scarcely without addition be brought into perfect fusion by the heat of our furnaces, till the fuel has converted it into steel. But steel is daily melted and cast into ingots, called *cast-steel*, by which it is rendered more uniform and similar in all its parts, and thereby fitter for being wrought into the finer kinds of utensils for which steel is employed. This cast-steel, when again reduced to the state of forged iron by cementation with absorbent earths, is the most uniform, equal, perfect iron which can be obtained.

*(e)* By conversion of iron into steel, this metal acquires a closer, more compact and finer-grained texture, greater hardness, elasticity, tenacity, density, sonorousness, and disposition to receive the magnetic property; and, as some say, an encrease of weight. It is also rendered less liable to rust by exposure to air; and less liable to emit sparkles when heated. The colors or irises which steel acquires by exposure to heat, and which are marks by which workmen know when any acquired heat is given, are not peculiar to steel and iron, but may also be produced by the same means on all other calcinable metals. These colors proceed from a calcination gradually advancing on that part of the metals which is exposed to air. And as the particles of metals in their different degrees of calcination are probably of different sizes, so they must acquire (according to Sir Isaac Newton's theory, which shews that the colors of bodies depend on the size of their integrant parts) different reflective powers, and exhibit changes of colors.

Steel may be made by fusion from the ore, or by cementation of forged iron with inflammable matters. Anciently, steel is said to have been made by immersing forged iron during some time in melted crude iron. Forged iron may also be changed into steel, as Wallerius affirms, by immersion in melted scoria; or by fusion with black flux, glass-gall, or borax; or by strewing sea-salt upon heated iron, and extinguishing it in dung.

Various opinions are formed concerning the cause of the difference between iron and steel. The most general opinion attributes this difference to the presence of a larger quantity of phlogiston

The affinities and medicinal virtues of ſteel are the ſame as thoſe of iron. *See* IRON.

STONES. This name is given in general, both in chemiſtry and in natural hiſtory, to many bodies of very different natures. But generally hard and compact bodies of an earthy nature are called *ſtones*.

As many different kinds of ſtones as of earths may be diſtinguiſhed. For the parts of every kind of earth being united and agglutinated together, are capable of forming, and actually do form ſtoney bodies. But as this union of

phlogiſton in the latter than in the former. Some authors, attending chiefly to the method of converſion by fuſion, conſider that operation only as a purification of the iron from earthy and heterogeneous particles, and ſteel merely as a more pure and perfect iron. Others, obſerving ſome ſimilitude in the texture of ſteel to certain kinds of caſt-iron, and the hardneſs of both theſe, without attending to their eſſential differences, have imagined that the ſtate of ſteel was intermediate betwixt that of caſt and that of forged iron. Laſtly, ſome metallurgiſts maintain, that the converſion of iron into ſteel is effected not by abſorption of phlogiſton, but by expulſion of ſulphureous or acid particles. To ſupport this opinion, they obſerve, 1. That ſteel is leſs diſpoſed than iron to ruſt; the cauſe of ruſt being, as they think, an acid contained in iron; 2. That ſteel emits fewer ſparkles under the hammer than iron, which ſparkles are found to be moſt frequent in iron abounding with ſulphur, as in red-ſhort iron; 3. That iron may be converted into ſteel by cementation with alkaline ſalts, capable of attracting the acid and ſulphur; 4. That in the preparation of ſteel by fuſion, the metal is rather expoſed to a diſſipation of its inflammable parts and burnt, than further phlogiſticated; and that this operation is accordingly called by workmen *the burning of ſteel*.

In the preparation of ſteel by fuſion, probably much of the earthy matters contained in the iron may be ſeparated, and any contained acid or ſulphur may be burnt or diſſipated. But the converſion of ſteel into iron by cementation with abſorbent earths, in which operation no acid or ſulphur can be abſorbed by the metal, ſhews that the difference between iron and ſteel does not conſiſt in the preſence of an acid or of ſulphur in the iron, but rather in the preſence of ſome ſubſtance in the ſteel, which the inflammable cementing ſubſtance can give to it, and of which abſorbent earths can deprive it. This ſubſtance has been generally believed to be phlogiſton; by the addition of which the metal acquires a new texture, together with the hardneſs, elaſticity, and other peculiar properties of ſteel.

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the integrant parts of any earth does not really change the nature of this earth; and as it always has the ſame eſſential properties, eſpecially when conſidered chemically; we refer to the word EARTH for all that we have to ſay concerning ſtones. The origin, and the ſenſible qualities by which naturaliſts diſtinguiſh different kinds of ſtones, are treated of in Mr. *Bomare's Dictionary of Natural Hiſtory.*

Several chemical preparations are alſo called ſtones, of which we ſhall here treat.

STONE (CAUSTIC), *or* COMMON CAUSTIC. *See* CAUSTIC.

STONE *of* BOLOGNA. This ſtone has been much celebrated for the property it has of becoming phoſphoric by calcination. It is a heavy ſelenitic ſpar. All ſpars of that kind, and alſo ſeveral other ſtones, have the ſame property. *See* PHOSPHORIC (STONES), *and* SPARS.

STONE (INFERNAL), *or* LUNAR CAUSTIC. *See* CAUSTIC (LUNAR.)

STONE (PHILOSOPHER's). This name is given by alchemiſts to the preparation by which metals may be tranſmuted, gold and ſilver made, and all the wonders produced of (what they call) the *great work*. *See the articles* METALS *and* METALLISATION.

SUBLIMATION. Sublimation is an operation by which volatile and ſolid ſubſtances are collected and obtained.

This operation is founded on the ſame principles as diſtillation, and its rules are the ſame, as it is nothing but a dry diſtillation. Therefore all we have ſaid on the article DISTILLATION is applicable here, eſpecially in thoſe caſes where ſublimation is employed to ſeparate volatile ſubſtances from others which are fixed or leſs volatile.

Sublimation is alſo uſed in other caſes; for inſtance, to combine two volatile matters; as in the operation of the ſublimates of mercury; or to collect ſome volatile ſubſtances; as *ſedative ſalt*, *ſulphur*, and all the preparations called *flowers*.

The apparatus for ſublimation is very ſimple. A matraſs or ſmall alembic is generally ſufficient for the ſublimation of ſmall quantities of matter. But the veſſels and the method of managing the fire vary according to the nature of the matters which ought to be ſublimed, and according to the form which ought to be given to the ſublimate.

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The beauty of ſome ſublimates conſiſts in their being compoſed of very fine, light parts; ſuch as almoſt all thoſe called flowers; as *flowers of ſulphur* and of *benjamin*, *ſedative ſalt*, and others of this kind. When the matters to be ſublimed are at the ſame time volatile, a high cucurbit, to which is adapted a capital, and even ſeveral capitals placed one upon another, are to be employed. The ſublimation is performed in a ſand bath, with only the preciſe degree of heat requiſite to raiſe the ſubſtance which is to be ſublimed; and the capitals are to be guarded as much as is poſſible from heat. The height of the cucurbit and of the capitals is well contrived to accompliſh this intention.

When along with the dry matter which is to be collected in theſe ſublimations, a certain quantity of ſome liquor is raiſed, as happens in the ſublimation of ſedative ſalt, and in the rectification of volatile concrete alkalis, which is a kind of ſublimation, a paſſage and a receiver for theſe liquors muſt be provided. This is conveniently done by uſing the ordinary capital of the alembic, furniſhed with a beak, and a receiver.

Some ſublimates are required to be in as ſolid and compact maſſes as their natures allow. Of this number are camphor, ſal ammoniac, and all the ſublimates of mercury. The propereſt veſſels for theſe ſublimations are bottles or matraſſes, which are to be ſunk more leſs deeply in ſand, according to the volatility and gravity of the matters that are to be ſublimed. In this manner of ſubliming, the ſubſtances having quitted the bottom of the veſſel, adhere to its upper part; and as this part is low and near the fire, they there ſuffer a degree of heat ſufficient to give them a kind of fuſion. The art, therefore, of conducting theſe ſublimations conſiſts in applying ſuch a degree of heat, or in ſo diſpoſing the ſand, (that is, making it cover more or leſs of the matraſs) that the heat in the upper part of the matraſs ſhall be ſufficient to make the ſublimate adhere to the glaſs, and to give it ſuch a degree of fuſion as is neceſſary to render it compact; but at the ſame time, this heat muſt not be ſo great as to force the ſublimate through the neck of the matraſs, and diſſipate it. Theſe conditions are not eaſily attained, eſpecially in great works.

Many ſubſtances may be reduced into flowers and ſublimed, but which require for this purpoſe a very great heat, with the acceſs of free air, and even the contact of coals, and therefore cannot be ſublimed in cloſe veſſels. Such are moſt ſoots or flowers of metals, and even ſome ſaline ſubſtances.

ſubſtances. When theſe ſublimates are required, the matters from which they are to be ſeparated muſt be placed among burning coals in open air, and the flowers are collected in the chimney of the furnace in which the operation is performed. This proceſs is called *ſublimation in the manner of Geber*. The *tutty*, *calamine*, or *pompholix*, which are gathered in the tops of furnaces in which ores are ſmelted, are ſublimates of this kind.

SUBLIMATE (CORROSIVE). This preparation, called alſo *mercury corroſive ſublimate*, is a mercurial ſalt, in which mercury is united with the largeſt quantity of marine acid with which it is capable of combining intimately.

This ſalt is called *ſublimate*, becauſe it can only be well prepared by ſublimation; and it is called *corroſive*, becauſe it is one of the moſt corroſive ſalts, or even the moſt corroſive of all ſalts with metallic baſes.

Corroſive ſublimate may be made by ſeveral proceſſes, which, however, are all ſo contrived, that the vapors of mercury and of marine acid ſhall meet in the ſame ſubliming veſſel.

The moſt uſual method conſiſts in mixing well nitrous mercurial ſalt with vitriol of iron and common ſalt, all well dried; and in promoting the ſublimation, as we have ſaid under the article MERCURY.

Another proceſs conſiſts in diſſolving mercury in concentrated vitriolic acid, as when turbith mineral is made; in triturating the white ſaline maſs remaining after this ſolution, previouſly dried, with an equal weight of dried ſea-ſalt; and in ſubliming this mixture in a matraſs with the heat of a ſand-bath, by encreaſing the fire till nothing more is ſublimed. This proceſs is given by Mr. Boulduc, in the Memoirs of the Academy for the Year 1730. Mr. Spielman obſerves, in his *Chemical Inſtitutions*, that Kunckel had given it formerly, in a work called *The Chemical Laboratory*.

In this operation, the acid of the vitriolic mercurial ſalt quits the mercury to unite with the alkali of common ſalt, to which it has a greater affinity, and with which it forms a Glauber's ſalt, that remains at the bottom of the matraſs after the ſublimation; while the marine acid on one ſide, and the mercury on the other, being both diſengaged, are reduced into vapors by the effect of heat, unite ſtrictly together, and form the corroſive ſublimate, which attaches itſelf to the upper part of the matraſs. This ſublimate

consists

consists partly of a white, semi-transparent, saline mass, and partly of shining crystals, composed of small and pointed plates.

This method of making corrosive sublimate is well-contrived, and seems preferable to the ordinary process; 1. Because the mercury, being previously dissolved by vitriolic acid, is as easily and perfectly mixed with common salt in this as in the ordinary process. 2. Because the acid of the vitriolic mercurial salt disengages powerfully and plentifully the acid of common salt; and that it is necessary, as we shall see, that the mercury should meet all the quantity of marine acid with which it is capable of uniting, to obtain the most corrosive sublimate. 3. The process of Kunckel and Mr. Boulduc is more simple than that with vitriol; the operator is less exposed to the acid vapors, the mixture from which the sublimate is separated is less voluminous, and therefore this method is justly preferred.

We think we ought to observe, upon the subject of this process, that almost all chemists, who have mentioned it since Mr. Boulduc, say, that it is made from a mixture of turbith mineral with common salt. This is an inaccuracy capable of leading readers into a mistake; for the vitriolic mercurial salt, employed by Mr. Boulduc, is very different from *turbith mineral*; it contains a large quantity of concentrated, vitriolic acid, which is very necessary in the operation; whereas turbith mineral contains very little or no vitriolic acid, when it has been well washed, according to Mr. Beaumé's experiments; and consequently, if turbith mineral be employed with common salt, in the proportions directed by Mr. Boulduc, we should obtain no sublimate, or but a very small quantity of a sublimate, which would not be corrosive.

The saline sublimates of mercury may be obtained by several other processes; for instance, the vitriol of the ordinary mixture may be omitted; we might also employ crude mercury instead of the mercurial nitre, and triturate it a long time with vitriol and salt, as Lemery says, or sublime the *white precipitate* alone. But we shall say no more of these methods, because they are all inferior to those we have mentioned, when a very corrosive sublimate is required; although some of them, as the sublimation of white precipitate, be very convenient, and may furnish a sublimate which probably is very good, when it is intended to be afterwards converted into *sweet mercury*, or *mercurial panacea*. But we must mention another method of making

making this ſaline ſublimate of mercury, propoſed alſo by Lemery, becauſe it is founded on a miſtake which ought to be made known.

This method conſiſts in triturating crude mercury with twice its weight of common ſalt; and in ſubliming this mixture, from which, according to Lemery, may be obtained a white ſublimate, leſs corroſive indeed, as he acknowledges, than the ordinary ſublimate, but which, nevertheleſs, is corroſive.

What Lemery ſays upon this ſubject is certainly true; but a modern author infers from thence, that mercury decompoſes common ſalt, that marine alkali has not a ſtronger affinity than mercury with marine acid, and that this experiment contradicts eſtabliſhed affinities. But none of all theſe conſequences is juſtly deducible. We explain this kind of paradox in the following manner.

For this purpoſe we muſt previouſly know, 1. That common ſalt, even when cryſtallized very regularly, is not a pure, homogeneous ſalt; but that it is intimately mixed with another ſalt, compoſed of marine acid, neutralized by a calcareous earth. 2. That the acid of this marine ſalt, with calcareous baſis, eſcapes merely by the action of fire, and without any other intermediate ſubſtance than a little moiſture. 3. That when mercury is ſublimed with ordinary common ſalt, that is, common ſalt which has not been purified from the mixture of this ſalt with calcareous baſis, it combines with the acid of this latter ſalt, and not with that of the true common ſalt, and forms a mercurial ſublimate. The proof of this is, that if, as Mr. Beaumé has done, common ſalt be diſſolved in water, and if into this ſolution ſome of the lixivium of ſoda be poured, till no more earth be precipitated, in which operation the ſalt with earthy baſis is evidently decompoſed, and is changed into a ſalt with baſis of fixed alkali; and if the pure ſalt remaining in the liquor be afterwards cryſtallized, and mixed with mercury, and the ſublimation be attempted, not a particle of ſaline ſublimate of mercury will be obtained. This experiment has been verified moſt ſcrupulouſly by Mr. Beaumé. Mercury ſingly cannot decompoſe common ſalt, therefore none of the conſequences inferred from the inaccurate experiment of Lemery are juſtly deducible. We might draw other conſequences not very favourable to the chemiſt alluded to, but we abſtain from them on account of his perſonal merit, and that we

we may not imitate the harſh and ſatyrical criticiſms which diſhonour his writings.

The ſublimates compoſed of mercury and marine acid, in which the metallic ſubſtance has had an opportunity of combining with all the acid with which it was capable of uniting, are evidently combinations of preciſe and determinate proportions of theſe two ſubſtances. Accordingly corroſive ſublimate, when well made, that is, as corroſive as it can be, being ſublimed a ſecond time with new marine acid, does not unite with a larger quantity of acid, nor become more corroſive. But we do not yet ſeem to have determined preciſely the proportion of marine acid, relatively to that of mercury, in the moſt corroſive ſublimate. According to Lemery, ſixteen ounces of mercury produce nineteen ounces of corroſive ſublimate; and, according to Tachenius, in the great works in Holland, where this preparation is made, 280 pounds of crude mercury furniſh 360 pounds of ſublimate; which would ſeem to prove, that the quantity of marine acid is greater in the ſublimate mentioned by Tachenius, than in that by Lemery. But as more of the mercury may be diſſipated when the quantity operated upon it is but ſmall, than when it is large, we can aſcertain nothing from comparing together the reſults of theſe two authors. However, we ſee that the quantity of mercury is much larger than that of the acid, ſince even in the ſublimate of Tachenius, the quantity of mercury was more than three times the quantity of acid; which deſerves to be remarked, as we ſhall ſee when we mention the principal properties of corroſive ſublimate.

The ſpecific gravity of this mercurial ſalt has not been hitherto determined, but it is evidently very conſiderable. It is very cryſtallizable, either by the uſual method for cryſtallizing ſalts, or by ſublimation, and the form of its cryſtals is the ſame in both caſes. It is not deliqueſcent, is difficultly wetted by water, and, in this reſpect, is ſimilar to arſenic. It is one of the ſalts which are very little ſoluble in water. According to the experiments of Mr. Spielman, an ounce of diſtilled water can diſſolve only thirty grains of it, with the aſſiſtance of a heat of fifty degrees of Fahrenheit's thermometer, which correſponds nearly to the tenth degree above the freezing point of Mr. Reaumur's thermometer; that is, that with this heat water can diſſolve only a nineteenth part of its weight of corroſive ſublimate.

All

All these properties of corrosive sublimate are naturall deducible from the large quantity of mercury which enter its composition: it perfectly resembles in this respect a the neutral salts, which contain a matter that is not saline intimately joined to the saline principle. But this circum stance is very remarkable, that corrosive sublimate has a the same time very contrary properties, by which it alt resembles those neutral salts in which the acid is but littl connected and imperfectly saturated with their basis. The properties are, 1. Its corrosive quality, which renders i one of the most violent and active poisons; and, 2. It capacity of receiving a much larger proportion of mercury which unites intimately with its acid, saturates it entirely and even so completely, that this salt, from being ver corrosive, is rendered, by this new addition of mercury, sweet sublimate, almost insipid, almost unsoluble in water and which has nothing in common with a neutral salt bu external appearance.

These latter properties of corrosive sublimate do not allow us to doubt that marine acid, although already united i this salt with a large quantity of mercury, and even very intimately, is yet very far from being saturated. Accord ingly this acid is, at the same time, in two states in som measure contrary. Several of the properties of corrosiv sublimate seem to shew that its acid is saturated as com pleatly as the acid of the most perfect neutral salts; whil other properties indicate that it is far from being com pleatly saturated.

To form a just idea of this singular state of marine aci in corrosive sublimate, we must first of all observe, that w should judge very erroneously of the state of the acid of neutral salt, if we considered the properties of this salt a depending only on its acid. We have elsewhere observed and we shall prove it further in this article, that bodie which are not saline, being united to acids in neutral salts have their peculiar action as well as these acids; and tha the properties of these salts are always the result of th combined properties of their acids and of their bases.

In the second place, we ought to recollect the distinctio we have made under the article SATURATION, into *relativ saturation*, and *absolute saturation*, which are two thing very different; because, in fact, it happens in many com- binations, that a principle is in a relative, perfect satura- tion with regard to another; that is, that it is united with all the quantity of this second principle which it can

dissolv

diſſolve, although it be very far from being in a ſtate of abſolute ſaturation; that is, from having ſo exhauſted all its action upon this ſecond principle, that no more remains to be exerciſed upon any other ſubſtance: For, if this were not ſo, we could not make any decompoſition by an intermediate ſubſtance. Thus in bodies compounded of two principles, ſuch as, for inſtance, neutral ſalts, one of their principles, and not the other, may be relatively ſaturated. Alſo one of the two principles, or both, may be in a perfect, relative ſaturation, although one or both be far from abſolute ſaturation.

Theſe things being premiſed, if we reflect on the properties of corroſive ſublimate, we ſhall eaſily perceive, 1. That the marine acid cannot be united with ſo large a quantity of mercury as it is in this ſalt, without being conſiderably approximated to a ſtate of abſolute ſaturation; hence corroſive ſublimate does not redden blue colors, has no acid taſte, does not attract the moiſture of the air, is very cryſtallizable, and not very ſoluble in water; in a word, that it is nearly in the ſame ſtate as ſeveral neutral ſalts, as vitriolated tartar and others, the acids of which are generally conſidered as being well ſaturated.

Secondly, We ſhall eaſily diſcover alſo, that although the acid of corroſive ſublimate approaches as much to abſolute ſaturation as the above-mentioned properties indicate, it is not nearly in a ſtate of relative ſaturation with regard to the mercury; ſince we know that it is capable of uniting again with a much larger quantity of mercury than is in corroſive ſublimate, as is ſhewn by the tranſformation of corroſive ſublimate into ſweet mercury; and we ſhall naturally conclude from theſe facts, that marine acid is capable of uniting with ſo large a quantity of mercury, that it cannot be entirely ſaturated with that ſubſtance, without exhauſting almoſt all the action it is capable of, and approaching nearly to the ſtate of abſolute ſaturation. Accordingly we ſee, that the properties of this acid become inſenſible, and are almoſt annihilated in ſweet mercury.

Thirdly, in reaſoning ſtill from principles above-mentioned, and in applying them to corroſive ſublimate, it will evidently appear, that although the acid of this ſalt is not nearly ſaturated with mercury, as we have obſerved, the mercury is nevertheleſs in a ſtate of relative ſaturation with regard to the acid; ſince, according to Mr. Rouelle's experiment, this ſalt cannot by any means receive a larger quantity of acid. But if, on the other ſide, we attend to

the quantity of mercury in corrofive fublimate, it v
appear very probable, that although this mercury be fa
rated with acid as much as it can be, and that in t
refpect it be in a ftate of perfect relative faturation, yet i
very far from having exhaufted upon this acid all
tendency it has to combination in general, and from be
in a ftate of perfect, abfolute faturation. In fact, on
fide, the aggregation of the mercury is broken in c
rofive fublimate, and confequently all its integrant pa
are capable of exerting their general tendency to combi
tion: but, on the other fide, thefe parts of mercury
united but to a very fmall quantity of acid, and proba
much of their tendency to union remains therefore unfa
fied; and we may reafonably conjecture, that from t
condition, or ftate of the mercury in corrofive fublima
proceeds the caufticity of that faline matter.

This notion will undoubtedly appear very bold to th
who are accuftomed to confider the caufticity of fal
matters as an effect only of the concentration and imperf
faturation of their faline principles.

But we repeat it, that we fhould judge very erroneou
of the properties of any compound body, if we were
attribute them to one of its principles only. On the co
trary, all the phenomena of chemiftry fhew, that all
conftituent parts of any compound contribute more or l
to all the properties of this compound. All the parts
matter are active, by the general tendency which they ha
to mutual combination. Nothing is purely paffive in natu
and if certain fubftances feem to us to be more inactive a
inert, it is becaufe their parts, having exhaufted all their te
dency and activity one upon another, by their union, are i
feeming reft, which we call faturation, and do really l
come inactive with regard to many other bodies: but wh
by fome caufe this union is broken, and its parts beco
difengaged, their effential activity then appears again in all
force; they refume all their tendency to combination, th
are in a violent ftate, till they find fome fubftance w
which they may unite, and fatisfy this tendency. T
violent ftate, this *nifus*, are the fame thing as caufticity,
rather this latter quality is an effect of the former qualit
rendered fenfible by their exertion upon animated bodi
Accordingly, all matter in nature, however inactive a
paffive it may feem, is capable of becoming, by the fepar
tion of its primary integrant molecules, an agent or folve
and a very powerful corrofive.

We conceive then, that in corrofive fublimate the aggregation of the mercury being broken, its primary integrant molecules are, on one fide, in this violent ftate, in this tendency to union above-mentioned; and, on the other fide, that as this tendency to union is only capable of being fatisfied partly, and imperfectly, by the marine acid, much of it remains unfatisfied, which gives a proportionable degree of caufticity to thefe molecules; fo that the mercury itfelf of the corrofive fublimate is corrofive, and probably much more fo than even the marine acid.

However ftrange and fingular this opinion may appear, we fhall find, by reflecting on the nature of corrofive fublimate, that no other caufe of its caufticity can be conceived. In fact, we muft allow that this falt is much more caftic than pure marine acid. For we are certain that a gros [72 grains] of this acid, or more, diluted in water, might be fwallowed without the leaft inconvenience; whereas half the quantity of corrofive fublimate, diluted in the fame, or a much larger quantity of water, would infallibly poifon. If then we fuppofe, that the caufticity of this falt is nothing elfe than the caufticity of the marine acid contained in it; how can we conceive that this acid, which, very far from being difengaged, and from poffeffing all its acidity in corrofive fublimate, is, on the contrary, united with more than thrice its weight of mercury, and is neutralifed fo as to form a very cryftallizable falt, not deliquefcent and not very foluble in water, which does not change to red the blue colors of vegetables, and gives no mark of acidity, can be infinitely more corrofive than the fame acid when free and difengaged? We might as well fay, that vitriolic acid is more corrofive in vitriolated tartar than when pure. The caufticity then of corrofive fublimate muft be chiefly attributed to the mercury, which is the predominant and leaft part of that faline fubftance. The mercury in corrofive fublimate appears to be nearly in a fimilar ftate as the earthy principle in fixed alkalis; that is to fay, its aggregation is deftroyed, at leaft in great meafure, and its quantity is very large in proportion to that of the faline principle. Accordingly, corrofive fublimate, inftead of changing the blue colors of vegetables to red, as acids do, changes them to green, as if it were an alkali, according to the obfervations of Mr. Rouelle; and in the fame manner as alkalis feem to owe their caufticity to the proportion and peculiar ftate of their earth, fo alfo does the caufticity of corrofive fublimate proceed from the quantity

and disposition of its mercury. This causticity, then, rather of an alkaline than of an acid kind.

An objection might be made here, that if the caustic of corrosive sublimate depended on the mercury, it ou to be encreased by encreasing the proportion of the mer ry; whereas we know, that the addition of more merc has a contrary effect, as we find from the instance of fw mercury.

The answer to this objection is not difficult. Altho the causticity of corrosive sublimate depends more on mercury than on its acid, we cannot doubt that this a also contributes to produce this effect, according to the neral rule, that all the principles of bodies conduce m or less to their properties: but the acid of sublimate is deed nearly in the state of absolute saturation, althoug is not quite in that state; and however neutralised it seem, it is yet capable of a certain degree of action: when it is totally saturated with mercury, it is then completely in a state of absolute saturation; because acid is capable of uniting with so much mercury, that w it is combined with this metallic substance, its relative turation and its absolute saturation are almost the s thing. We need not then be surprized, that in this res the causticity of the sublimate is considerably diminish but, besides, when the quantity of mercury much exc what ought to be contained in corrosive sublimate, we easily perceive that the parts of the mercury, being pr nearer the parts of the acid, are also more and more united gether, and approach more nearly to the state of aggregat in which state mercury cannot have any causticity. *Se the properties, chemical and medicinal, of corrosive sublimate articles* ACID (MARINE), *and* MERCURY.

SUBLIMATE (SWEET). *See* MERC (SWEET).

SUBLIMATE (RED). If a solution of mer in nitrous acid be evaporated and dried, and then exp to a strong heat in a matrass, the nitrous acid will be s rated from the mercury in great measure, and will be c pated in red vapors; the saline mass remaining in matrass acquires at first a yellow color, which afterw changes to an orange color, and lastly to a red. Th called *red precipitate*. But by exposing this red matte greater heat, it is sublimed, while its color is prese It is then called *red sublimate*. This sublimate is not

SUGAR. Sugar is a cryſtallizable eſſential ſalt, of a ſweet agreeable taſte, contained, more or leſs plentifully, in many kinds of vegetables; but in moſt of them in ſo ſmall a quantity, or confounded with ſo much extraneous matter, that it cannot be obtained from them with profit.

The plant which contains and furniſhes moſt of this eſſential ſalt is a kind of reed, which grows in hot climates, called *ſugar-cane*.

The method uſed for the extraction of ſugar from the cane, is the ſame as is employed for the extraction of any eſſential ſalt from the juices of plants, with this difference, that as ſugar and liquors containing it are very fermentable, this ſalt is not obtained by a regular cryſtallization, but by a much ſpeedier coagulation.

After having entirely expreſſed the juice from ſugar-canes, it is boiled in caldrons at different times with lime-water and lixivium of aſhes, both to clarify it, and to evaporate it ſo much, that when it cools, moſt of it coagulates, or confuſedly cryſtallizes. This coagulated matter is to be ſeparated from the remaining liquor, which is called *melaſſes*. From this liquor, by fermentation and diſtillation, an ardent ſpirit is obtained, called *rum*. The ſolid ſubſtance, or ſugar, is mixed with much mucilaginous extractive matter, which renders it ſoft and red. To purify, or, as it is called, to *refine* it further, it muſt be rediſſolved in pure water, and its heterogeneous parts muſt be ſeparated by boiling with quicklime and lixivium of aſhes, to which is added a certain quantity of ox's blood, for a more perfect clarification and purification. Laſtly, the ſugar, when refined, is put into earthen conical veſſels open at both ends, the ſmaller of which is turned downwards. *(f)* The ſugar is covered with ſome earth moiſtened with water. This water filtrates through the ſugar, diſſolves the mucilage or ſlime which ſtill adheres to the ſugar, and flows out at the opening in the lower point of the conical veſſel. In this manner is obtained this pleaſant and uſeful ſalt. To whiten and purify it perfectly many clarifications are required, the cauſe of which is chiefly a ſlimy matter, like honey, that adheres to it.

*(f)* The aperture in the lower narrow part of the mould is ſtopt with a plug when the ſyrup is poured into the mould, and when the ſugar is become ſolid, the plug is drawn out, that the mucilaginous or treacly matter may drain.

This essential salt is soluble in water, like all other salts and even is one of those salts that is soluble in the smallest quantity of water.

It is crystallizable; and its crystals, when slowly and regularly formed, are beautiful and transparent, called *sugar-candy*. *(g)* This salt consists of an acid united with a large quantity of a very attenuated and mucilaginous earth, and with a certain quantity of sweet and not volatile oil, which is in a state perfectly saponaceous, that is, entirely soluble in water by means of the acid.

Sugar, when distilled, yields a phlegm, an oily empyreumatic acid, a small portion of colored empyreumatic oil and leaves a considerable quantity of residuous coal.

This salt is very susceptible of the spirituous fermentation, when it is diluted in a sufficient quantity of water and, like all the other substances capable of that fermentation, it is very nutritive to animals.

The nutritive and fermentative parts of vegetables have not been sufficiently examined, to enable us to determine whether they be perfectly of a saccharine nature. We know, however, that they furnish by analysis the same principles, and nearly in the same proportion; that they all have a sweet, agreeable, and generally saccharine taste that every vegetable or animal substance that is saccharine is also nutritive and fermentative; and, lastly, that genuine sugar may be obtained from most of them.

Mr. Margraaf has obtained sugar from the roots of several plants, as from carrots, parsnips, white and red beets. Some of these roots, as, for example, the white beet, furnished a very considerable quantity of sugar. He obtained about half an ounce of sugar from half a pound of the dried root. This able chemist, considering that sugar is soluble in spirit of wine, and that the mucilaginous parts of plants are not soluble in that fluid, easily obtained a pure sugar by digesting the dried roots in that spirit, and by evaporating the liquor. Afterwards, hoping to find a cheaper method

*(g)* The crystallization of sugar, or the formation of sugar-candy, requires peculiar management. The syrup, boiled down to a proper consistence, is poured into pans placed in a room the air of which is rendered very hot; by which means the transition of the sugar from a fluid to a solid state is very slowly effected, and the parts of the sugar are allowed, notwithstanding the viscidity of the liquor, to arrange themselves according to their peculiar form.

that his discovery might be useful, he attempted successfully to obtain sugar by the ordinary process very little varied. He could not indeed obtain a very pure sugar without repeating very frequently the solutions, clarifications, and other operations, as may be seen in his Memoir, or in the Eighth Dissertation of his *Opuscules Chemiques*. But at last he did succeed; and we have reason to hope, that by improving the process, much sugar may be obtained from other vegetables, as from green peas, cabbage, green farinaceous grains; from several trees, as the sycamore, and the birch trees, some of which have more of a saccharine taste than several of the plants from which Mr. Margraaf extracted sugar. *(b)*

The chief, and perhaps the only difficulty to be surmounted in this extraction of sugar, proceeds from the viscid matters, which are so mixed and blended with the saccharine substance of plants, that they prevent its crystallization. The saccharine and mucilaginous parts might be separated from each other by means of a menstruum, which could dissolve the sugar and not the slimy substance, or which could dissolve the latter and not the former. To discover such a menstruum seems to be the proper object of inquiry for those who would prosecute this subject.

SUGAR *of* LEAD. *See* SALT *of* LEAD.

SUGAR *of* MILK. *See* MILK.

SULPHUR. No word has been so much used by chemists, and at the same time so much abused, as *sulphur*. By this the ancient chemists denoted all inflammable substances, of whatever nature they might be. Sulphur, according to them, is one of the principles of bodies. They spoke continually of the sulphurs of metals, of the sulphurs of plants, of the sulphurs of animals: oils, ardent spirits, resins, bitumens, were all sulphurs. In every thing they

*(b) Maize*, or *Indian-corn*, while green, contains a liquor from which the American savages are said to extract sugar. Sugar may also be extracted from the *Asclepias caule erecto simplici annuo* (Linnæus Hort. Cliff.), and from many flowers collected while the morning dew is on them. Encyclop. tom. xv. p. 617. & Mem. of the Swedish Acad. tom. xiii. But the vegetable which yields the largest quantity of sugar, next to the sugar-cane, is the kind of maple tree called the *sugar-maple*. The methods employed for the extraction of the sugar from this tree, in Canada, are related by M. Gautier, in the *Mem. des Sçav. Estrang.* tom. 2. and by M. Kalm, in the *Swedish Memoirs* for 1757.

found a ſulphur. Even now, alchemiſts, and others w
have only confuſed id as of chemiſtry, from reading c
chemical books, talk inceſſantly and deciſively of ſulphu

To Beccher, and ſtill more to the illuſtious Stahl, t
owe the ſimple, clear, and preciſe ideas which we n
have of the ſeveral kinds of inflammable ſubſtances, form
ly confounded under the general name of ſulphur. By t
ſagacious diſtinction they have made between the pure a
ſimple inflammable principle, and the more compound
bodies which contain it, and owe their inflammability to
we acquire a knowledge of the true theory of ſulphur a
of all inflammable ſubſtances.

Since Stahl has unfolded this ſublime theory, we kn
that the inflammable principle is identical, always alil
and the ſame in every body; that this principle by its co
bination with different ſubſtances produce all the inflamm
ble matters which we know. Oils, fats, reſins, bitume
ardent ſpirits, coals, metals, ſulphur properly ſo called,
common ſulphur, are ſo many compounds, all which ha
the common property of burning, becauſe they all cont
the principle of inflammability; but which differ in other
ſpects, becauſe this principle is united to different ſu
ſtances, and in different proportions.

Stahl has eſtabliſhed theſe important truths, chiefly
examining, by decompoſing, and by re-compoſing comm
ſulphur, and by demonſtrating from the moſt ſatisfacto
experiments, that this ſulphur conſiſts of vitriolic ac
united with the pureſt and ſimpleſt inflammable princip
We ſhall relate, as ſhortly as we can, the reſults of his
ſearches upon this ſubject.

Nature probably forms, and combines daily, mine
ſulphur within the earth. This ſubſtance is abundant
diffuſed in many places, eſpecially where metallic miner
exiſt. Sulphur almoſt pure, called *native ſulphur*, is fou
in volcanos and in grottos, where it is ſublimed in form
tranſparent cryſtals. But the greateſt quantity of ſulph
which exiſts naturally, is combined with metals in ores, a
eſpecially in pyrites. As ſulphur is fuſible and volati
it is procured from theſe minerals by diſtillation and ſub
mation. *See* SMELTING *of* ORES.

Sulphur, ſuch as it is in commerce and in arts, is o
pale yellow or citron color, of a diſagreeable and pecul
ſmell, which is rendered more ſenſible when the ſulphur
heated or rubbed. By rubbing, ſulphur is electriſed.
ſpecific gravity is much greater than that of water, and l
th

than that of earths and ſtones. It is brittle and pulverable; although it may alſo be eaſily ſoftened, as we ſhall afterwards obſerve.

Sulphur ſeems to be incapable of receiving any alteration from air or from water, ſeparately or conjointly, nor even from fire in cloſe veſſels. Sulphur, expoſed to heat in a ſubliming veſſel, is melted with a very gentle heat, and then is ſublimed, and adheres to the capital, forming ſmall very fine needle-like cryſtals, called *flowers of ſulphur*. This ſublimed ſulphur is eſſentially the ſame as that which has been only melted: and it may be thus ſublimed many times without alteration. If ſulphur, which has been expoſed to no more heat than ſufficient to melt it, be cooled very gradually, it cryſtallizes in form of many needles croſſing each other. Some of theſe pointed cryſtals may alſo be obſerved in the interior parts of the lumps of ſulphur which have been melted and caſt into cylindrical moulds, as they are commonly ſold; becauſe the center of theſe cylindrical rolls is more ſlowly cooled than the ſurface. Sulphur alſo gives this needle-like form to cinnabar, to antimony, and to many other minerals containing it.

Sulphur is inflamed and burnt by expoſure to fire and to air. But the phenomena which it exhibits are different according to the manner of its combuſtion. When it is very hot and burns quickly, its flame is ardent and capable of kindling inflammable bodies, but is always bluiſh, not very luminous, and not accompanied with any ſoot or ſmoke, but with an acid vapor of a penetrating and ſuffocating ſmell. This vapor, confined by means of a glaſs bell, and received into the vapor of water introduced for that purpoſe into the ſame bell, is called *ſpirit of ſulphur*, which we ſhall afterwards ſhew is the vitriolic acid, that is at firſt volatile and ſulphureous, from the ſmall quantity of inflammable principle that it ſtill retains, but which afterwards becomes pure vitriolic acid.

If, on the contrary, ſulphur is burnt in open air, but very ſlowly, its flame is ſo little luminous, that it can be perceived only in the dark, like a ſmall bluiſh glimmering light; and ſo little ardent, that it cannot kindle the moſt inflammable ſubſtances. Mr. Beaumé proves this truth by a very fine and curious experiment, in which he burns all the ſulphur that is contained in gun-powder without kindling the powder. When this experiment is made, a tile muſt be equally heated and to a certain degree, that is, a little more than is requiſite for the ſucceſs of the experiment.

ment. Upon this tile, thus heated, ſome grains of gunpowder are thrown, to diſcover the degree of heat; and if the heat be too great, the powder detonates, from time to time, as is uſual. More powder is thrown on the tile, till this be ſo much cooled, that the powder does not fulminate, but only emits a white ſmoke. If the tile and powder be carried in this ſtate to a dark place, the vapor, which ſeemed to be a white ſmoke, will then appear to be a true flame, but very bluiſh and faint; which will continue till all the ſulphur of the powder be conſumed, if the tile remains ſufficiently hot for that purpoſe.

We may eaſily perceive, that when the ſulphur burns thus weakly and ſlowly, a part of its inflammable principle is diſſipated without inflammation, and that conſequently the acid which is diſengaged by that combuſtion, ought to be more volatile, penetrating, and ſulphureous, than it is when the inflammation is more rapid. Hence, when we would obtain much volatile ſulphureous acid by burning ſulphur, as for the whitening of ſtuffs by the vapor of ſulphur, it muſt be burnt very ſlowly, as Stahl has well remarked.

As nothing remains after the burning of ſulphur, unleſs ſome extraneous body happens to be mixed with it; and as, during this combuſtion, nothing is perceptible but two matters, one of which is deſtroyed by the inflammation, and another which has the properties of the vitriolic acid; we may conclude, that ſulphur is compoſed of an inflammable matter, and of vitriolic acid. But the examination of the other properties of this ſubſtance will render our knowledge of its nature and its principles more compleat and accurate.

Sulphur heated ſo much as to burn, and thrown while melted and burning into water, is very quickly fixed or rendered ſolid; but in this experiment it acquires a conſiderable degree of ſoftneſs, which indeed only laſts a certain time; after which the ſulphur recovers its natural conſiſtence and brittleneſs.

Pure acids ſeem to have no action upon ſulphur, eſpecially in the humid way. But Mr. Beaumé has obſerved, that if concentrated vitriolic acid be poured upon ſulphur, and heated to a certain degree, this ſulphur will liquefy and appear in the water like an oil; and when it is cooled, it will have a green color; which ſeems to ſhew ſome action of the acid upon the ſulphur. But this ſulphur is not in any other reſpect changed.

Alkalis

Alkalis fixed and volatile, and even calcareous earths, diſſolve ſulphur, render it more or leſs ſoluble in water, and form with it compounds called *livers of ſulphur*. The ſulphur may be ſeparated and precipitated, by means of an acid, from theſe ſubſtances; in which caſe, it appears, as before, only much divided.

This experiment ſhews that ſulphur is not decompoſed by uniting with alkalis. Nevertheleſs, the ſtrong fetid ſmell of liver of ſulphur, and the facility of decompoſing ſulphur while it is thus united with an alkali, ſhew that, in this combination, the connexion of its parts are weaker than when it is uncombined. *See* LIVER *of* SULPHUR.

Sulphur detonates with nitre, from its inflammable principle, and is then decompoſed by the combuſtion of this principle. But in this detonation we perceive only the two principles of ſulphur above-mentioned. Its phlogiſton, together with that of the nitrous acid, maintains the flame of this detonation, and the acid of the ſulphur is afterwards found to be combined with the alkali of the nitre, with which it forms a vitriolated tartar, called *ſal polychreſt of Glaſer*. This is completely proved in the experiment of the *chyſſus of ſulphur*. *See* CLYSSUS.

Sulphur unites eaſily with all metallic matters, excepting gold, platina, and zinc; at leaſt we have not found the means of uniting it with theſe, directly, and without ſome intermediate ſubſtance. The degrees of affinity with which ſulphur combines with thoſe metals to which it may be readily united, are different; for it not only unites more eaſily and abundantly with ſome than with others, but it alſo quits thoſe with which it has a leſs affinity, to unite with others to which it has a ſtronger affinity.

The affinities of ſulphur, according to Mr. Geoffroy's Table, are, fixed alkali, iron, copper, lead, ſilver, regulus of antimony, mercury, and gold; and according to Mr. Gellert's Table, they are, iron, copper, tin, lead, ſilver, biſmuth, regulus of antimony, mercury, arſenic, and cobalt: gold and zinc are marked in this Table as being incapable of uniting with ſulphur.

The compounds formed by ſulphur with different metals are different; but all of them poſſeſs a metallic luſtre, without any ductility: theſe combinations of ſulphur and of metals are very frequently found in a natural ſtate. Almoſt all the metals which we dig from the earth are naturally found combined with ſulphur, forming moſt of the ores and metallic minerals.

The

The properties of the combinations of ſulphur with metallic matters have been little examined, becauſe theſe combinations are not of any uſe; but, on the contrary, when they are found, they muſt be decompoſed, that the metals may be obtained ſeparately from the ſulphur. Nevertheleſs, we know not only that metals have different degrees of affinity with ſulphur; in conſequence of which property, ſulphur may be and actually is, in many metallurgical operations, ſeparated from ſome metals by means of others, to which it is more diſpoſed to unite; but we alſo know that ſulphur facilitates the fuſion of hard and difficultly fuſible metals, ſuch as copper and iron; and that, on the contrary, it renders the ſoft and fuſible metals, as tin and lead, leſs eaſily fuſible. Theſe ſingular effects ſeem to proceed from the difference of the affinity of ſulphur to the ſeveral metals.

Sulphur may be ſeparated from metallic matters by ſeveral methods. Firſt, as ſulphur is volatile, and as theſe metallic matters are fixed, or at leaſt leſs volatile than ſulphur, the mere action of fire is ſufficient to ſeparate ſulphur from moſt metals. As this method is ſimple, and not expenſive, it is generally employed to ſeparate ſulphur from ores; which effect is produced by the *torrefaction* or *roaſting* of theſe ores. We muſt, however, except the ore of mercury, or native cinnabar, and alſo the combinations of arſenic with ſulphur, which cannot be decompoſed without an intermediate ſubſtance, from the great volatility of mercury and of arſenic; although, perhaps, it would not be impoſſible to ſeparate the ſulphur from thoſe compounds, without an intermediate ſubſtance, by a heat carefully applied, long continued, and with acceſs of air.

Secondly, ſeveral combinations of ſulphur with metals may be decompoſed by means of acids, which diſſolve the metallic matter, without attacking the ſulphur. But in ſeveral of theſe compounds, the ſulphur defends the metal from the action of the acids; and this ſeparation by acids does frequently not ſucceed, or ſucceeds only imperfectly. Crude antimony is one of the ſulphurated metallic ſubſtances from which ſulphur may moſt eaſily be ſeparated by means of aqua-regia. This menſtruum ſeizes readily the regulus of antimony contained in mineral antimony, and ſeparates from it the ſulphur, which then appears in form of a white powder.

Laſtly, we may, as we have already ſaid, ſeparate ſeveral metals from ſulphur by means of other metals, to which the

ſulphur

lphur has a greater affinity. This ſeparation is practiſed ſeveral operations, as in the *dry parting*, the *purification of ld by antimony*, the *decompoſition* of *cinnabar*, of *orpiment*, d of *crude antimony*. *See the articles* ESSAY *of* ORES; RES PYRITES; SMELTING *of* ORES; *and all the articles of ſeveral metals and ſemi-metals.*

Oils and oily matters, of whatever nature, are all capable acting upon ſulphur, and of diſſolving it. Several ſolu-ns of ſulphur in eſſential oils are uſed in pharmacy, ich have been named from the oils employed; as *terebin-nated balſam of ſulphur*, and *aniſated balſam of ſulphur*; d other ſolutions have been made of ſulphur in expreſſed eet oils, as that in the oil of nuts, called *Rulland's balſam ſulphur*.

Sulphur cannot be diſſolved in oils, according to Mr. aumé, without a heat ſufficient to melt it. A larger antity of ſulphur is kept diſſolved in the oil while hot n when cold; and accordingly, when oil has been ſatu-ed with ſulphur by means of heat, a part of the ſulphur arates from it when it cools, in the ſame manner as many s, kept diſſolved in hot water, are cryſtallized when the ter becomes cold. The analogy betwixt the ſalts and phur in theſe inſtances is alſo obſervable in this reſpect, t when the oil in which the ſulphur is diſſolved is very dually cooled, the ſulphur cryſtallizes regularly, as ſalts in ſimilar circumſtances.

Sulphur is not decompoſed by the union which it con-cts with oils, when no more heat is applied than is ne-ſary for the ſolution. For the ſulphur, when ſeparated m the oil, is found to be poſſeſſed of all its properties. appears, however, that the connexion of its principles is ſome meaſure altered by this combination; at leaſt, if may judge from the color and ſmell of the balſams of lphur, which are different from thoſe of the ſulphur, or of oil.

But when the balſams of ſulphur are diſtilled with a heat pable of entirely decompoſing them, the ſulphur itſelf is en alſo decompoſed. For according to an experiment ade by Homberg, and ſome other chemiſts, the ſame inciples are obtained by this diſtillation continued till the atter in the retort be dry, as are obtained from a combina-on of pure vitriolic acid with oils. Theſe principles are, rſt, a portion of oil, when the oil of which the diſtilled alſam is compoſed was an eſſential oil; then ſome volatile lphureous acid, which is at firſt watery, and afterwards becomes

becomes ſtronger; along with this acid more oil riſes, whic becomes more and more thick towards the end of the diſtil lation; and laſtly, when the retort has been red-hot, nothin remains but a fixed coal.

From the above-mentioned products we find, that th ſulphur and part of the oil are decompoſed in this diſtill tion. The vitriolic or ſulphureous acid certainly proceed from the ſulphur: for no quantity of that acid can be ob tained from any kind of oil, nor from any pure vegetable o animal oily matter. The water contained in this ſulphur ous acid is evidently a part of the water which is a princip of the oil: for the vitriolic acid of the ſulphur being in ſtate perfectly concentrated and dry, as ſhall be afterward ſhewn, could not otherwiſe contain ſo much water as does in this operation. Laſtly, the coal which remain after the operation, is a portion of the earth that is a princip of the oil, intimately united with ſome of the inflammab principle either of the oil or of the ſulphur, or moſt pro bably of both.

In this mutual decompoſition of ſulphur and oil, th concentrated acid of the ſulphur ſeems to attack the water principle of the oil, while its phlogiſton, which by th new union loſes much of its adheſive power, is partly di engaged, and confounded with the phlogiſton of the oi Thus the ſulphur is changed into volatile ſulphureous acid And probably alſo a certain quantity of inflammable prin ciple is diſengaged in this experiment, and is diſſipated i vapors. Such appear to be the phlogiſtic vapors, which kindling at once, produce the terrible exploſions that ſome times happen when the combinations of oil and of ſulphu are careleſly heated. Hoffman relates a ſingular inſtance o an exploſion of this kind, which happened in a laboratory where balſam of ſulphur had been left in a matraſs upon th fire.

Spirit of wine does not act ſenſibly upon ſulphur, unle theſe two ſubſtances be applied to each other in the ſtate o vapor, as the Count de Lauraguais diſcovered. Man combinations, now believed to be impoſſible, might b effected by employing the moſt powerful means in chemiſtry namely, an extreme diviſion and ſeparation of integran parts, as the Count de Lauraguais has done in the above mentioned fine experiment. By this means chiefly, w may arrive at great diſcoveries. From the above-mentione properties of ſulphur we learn, that this ſubſtance is com poſed of vitriolic acid and phlogiſton. Stahl demonſtrate

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his important truth ſo clearly and compleatly, as to ſhew he true ſtate, and even the proportion of the principles of ulphur, not only from its analyſis, but alſo by its artificial ompoſition, of which we ſhall now ſpeak.

The proceſs by which this chemiſt made ſulphur exactly milar to native ſulphur, conſiſts in mixing and melting ogether in a crucible equal parts of fixed alkali and of vi-iolated tartar, to which is added a quantity of powdered harcoal equal to a fourth part of the weight of the ſalts. he matter is to be ſtirred with an iron rod, that the char-oal may be well mixed with the ſalts; the crucible is to e covered; and a pretty ſtrong heat is to be ſuddenly plied, and continued during a very ſhort time. The rucible is then to be removed from the fire, and the melted atter is to be poured upon a ſtone previouſly greaſed. his matter, which ſparkles when it is poured, is coagulated y cold, and becomes a brittle maſs, of a deeper red color an ordinary liver of ſulphur; but it has the ſmell, the lubility, the deliqueſcency, and all the other properties liver of ſulphur. By diſſolving it in water, and by add-g any acid to the ſolution, an artificial ſulphur will be ecipitated, which being collected and dried, is found not differ from natural ſulphur.

The color of this dry liver of ſulphur is redder than that the ordinary preparation of that name; and when diſ-lved in water, its ſolution is of a deep green color, in hich reſpect alſo it differs from the ordinary liver of ſul-hur. Theſe differences proceed from ſome foreign matter nited with the liver of artificial ſulphur; and this foreign atter is a part of the charcoal employed in the proceſs for aking the ſulphur. For the whole quantity of charcoal dded not being converted into ſulphur in this proceſs, me part of it is diſſolved by the liver of ſulphur as ſoon this is formed; charcoal being ſoluble in liver of ſulphur, the younger Mr. Rouelle has ſhewn.

We ſhould be much miſtaken if we believed, that the lphur obtained in this operation exiſted ready formed in ny of the ſubſtances employed, and that it is only extracted om theſe. Glauber had, before Stahl, performed this peration, by employing his *ſal mirabile* inſtead of vitrio-ated tartar; but from his ignorance of the true theory, he ell into this miſtaken opinion. Boyle alſo, having pro-ured ſulphur by diſtilling to dryneſs a mixture of vitriolic cid and oil of turpentine, did not believe that he had roduced this ſulphur, but only that he had ſeparated it from

from the ſubſtances employed. On the contrary, we know certainly from many proofs, that not a particle of ſulphur exiſts in vitriolic acid, nor in neutral vitriolic ſalts with baſis of fixed alkali, nor in very pure alkalis, nor in any oil, nor in any vegetable coal; and conſequently the ſulphur obtained in theſe operations is a new product, reſulting from the union of the vitriolic acid with inflammable principle of the vegetable coal, as Stahl has advanced.

The fixed alkali mixed with vitriolated tartar in this proceſs is not abſolutely neceſſary; for ſulphur may be produced merely from any vitriolic ſalt with any inflammable matter, made red-hot together: but the alkali is uſeful in this proceſs, by facilitating the fuſion of the vitriolated tartar, and by preventing the diſſipation and combuſtion of moſt of the ſulphur, as ſoon as it is formed. This alkali unites with this ſulphur, and forms a liver, in which the ſulphur is leſs diſpoſed to burn, and be diſſipated, than when it is not engaged with any fixed and incombuſtible body.

Although, rigorouſly ſpeaking, the vitriolic acid itſelf, when diſengaged, and treated properly with any combuſtible body, can always produce ſulphur; nevertheleſs, in this operation, an acid engaged in ſome baſis to which it adheres ſtrongly ought always to be employed; ſuch is the acid in vitriolated tartar, in Glauber's ſalt, and even in almoſt all neutral vitriolic ſalts with earthy and metallic baſes; becauſe vitriolic acid cannot contract with the inflammable principle the intimate union which is requiſite for the production of true ſulphur, excepting it be deprived of all the water that is not neceſſary to its ſaline eſſence; that is to ſay, in its higheſt degree of concentration, and even in a dry ſtate. Beſides, if a red heat be not abſolutely neceſſary to effect this combination, as the ſulphur formed in the ſolution of ſome metallic matters by vitriolic acid ſhews, it is nevertheleſs very uſeful. But when a diſengaged vitriolic acid is employed; as, for inſtance, when a mixture of this acid with an oil is diſtilled; the greateſt part of the acid is converted into volatile ſulphureous acid, while any moiſture remains in the mixture, and the ſulphur is not produced till towards the end of the operation, when the matter in the retort is dry; and then the concentrated remaining portion of vitriolic acid, uniting with the phlogiſton of the earthy coal of the oil, forms the ſulphur.

Hence, ſulphur may be more copiouſly and quickly made, by applying to a coal vitriolic acid engaged in ſome baſis, which

enders it so fixed that it may, by fire, be deprived perfluous water, and even be made red-hot, than ying this acid in any other manner. Accordingly rocess is the best. These considerations on the best of making sulphur are of little value, because ulphur is plentiful and cheap. But the discovery hur can be thus made, and the theory which Stahl concerning this subject, are very important. For nce we not only learn the nature of sulphur, of e had an imperfect, and even false idea; but, nuch more valuable, we may thence draw a number mportant and very general inferences, the chief of e shall now mention.

vitriolic acid and the inflammable principle cannot phur by combining together; unless they both be of all moisture, and be perfectly dry. Hence no ble body which contains in its composition water, oils and ardent spirits, can form with this acid, but only a volatile sulphureous acid, till these in- e matters be decomposed, and reduced to a state of ich is one of the dry combinations of the inflam- inciple.

lly, the inflammable principle of all combustible always capable of forming sulphur with the acid, provided it be, or can be made, dry. Thus irits, oils, and oily matters, or rather the coals of substances, and all combustible metals, do always hur when treated properly with vitriolic acid; and the nature of the combustible body be which trans- hlogiston to the acid, the sulphur resulting from ys the same, and always perfectly similar to natural Hence an important proposition is inferred, that inflammable principle exists, which is always the ether it resides in resins, in bitumens, in oils and als, or in metals. For if the inflammable prin- all these combustible bodies was not the same these bodies might form different sulphurs iolic acid, which we find from experience they .

y, vitriolic acid always quits any body with which to be combined, when it can unite with the in- principle of any other body, and with this prin- ns sulphur when it is properly applied. Hence, has a greater affinity with the inflammable prin- with any other substance; and hence we may

 discover,

discover, by means of phlogiston, the vitriolic acid, wit whatever substances it may be combined; and reciprocall we may, by means of vitriolic acid, discover the inflam mable principle in all bodies in which it exists in a com bustible state.

Fourthly, the principles and properties of sulphur bein known, we may deduce from these properties a more ac curate knowledge of the particular nature of the inflam mable principle, by comparing the difference betwee sulphur, volatile sulphureous acid, and pure vitriolic aci From this comparison we find, that the smell and color o sulphur, its volatility, its constant dryness, its unsolubilit in water, which properties do not belong to vitriolic aci are produced by the inflammable principle, that possesses a these qualities in itself, or that is, at least, capable of com municating them to the compounds in the combination o which it enters. *See the Article* PHLOGISTON.

Fifthly, we have reason to believe, that the inflammabl principle possesses eminently the above-mentioned properties for we know that the quantity of it in sulphur is much le than the quantity of the vitriolic acid. Stahl has mad a fine experiment to discover nearly the proportion of th two principles of sulphur. This experiment consists i putting a quantity of powdered liver of sulphur upon a earthen-ware plate, and placing this plate upon a fire s gentle that the liver of sulphur shall not be melted, nor eve so softened that it can run into lumps. This powde must be stirred, and the fire must be encreased towards th end, till no smell be perceived. The remaining matte is to be dissolved in water, and by crystallization a very pur vitriolated tartar is formed.

In this operation, the inflammable principle of the sul phur is gradually dissipated without any sensible combustion and its acid combines, or remains combined, with the alka of the liver of sulphur. But we must observe, that t render this experiment exact, and to draw from it accurat conclusions, the following conditions are required: 1st, w must know precisely the quantity of sulphur contained in th liver of sulphur employed; 2dly, the liver ought to contai rather too much than too little fixed alkali, that there ma be certainly enough of it to saturate all the acid of th sulphur; lastly, no part of the sulphureous acid must escap during this decomposition; and therefore no smell of th acid, but only that of the liver of sulphur, which is ver different, ought to be perceived. To prevent this dissipa tio

of volatile acid, we muſt proceed very ſlowly; and operation accordingly requires a long time. Mr. ndt, who has carefully repeated it, found from the ntity of vitriolated tartar obtained by this method, that, ulphur, the proportion of inflammable principle is to of the vitriolic acid as three to fifty; that is, that ſulphur contains only one ſixteenth of its weight of mmable principle.

ich is the ſtate of our actual knowledge concerning the re and principles of ſulphur, which Stahl has rendered compleat and accurate. We find that ſulphur is a pe- r combination of the pureſt inflammable principle with olic acid; that not a particle of oil is contained in it; it is therefore very different from bitumens, with h it has been long confounded; that, ſtill more impro- , the name of ſulphur has been given to all other mmable bodies, which are entirely different from it; we ought therefore to confine the name of ſulphur to compound formed of pure vitriolic acid and pure phlo- n, unleſs we would apply it, as the ancient chemiſts done, to the inflammable principle itſelf, which they d the *principal ſulphur*; but in this caſe we ought to another name to mineral ſulphur.

et us remark, nevertheleſs, on the ſubject of the name *ur*, that as other acids beſides the vitriolic can alſo ract an intimate union, and form compounds with pure giſton, this name may be generally applied to all pounds of pure acid and phlogiſton, which may be nguiſhed from each other by adding the name of the ; as *vitriolic ſulphur*, *nitrous ſulphur*, and *marine ſul-* , if any ſuch ſulphur does exiſt: but let us alſo ark upon this ſubject, that we can give this name of *ur* to thoſe compound bodies only which do not contain oil; this condition being eſſential to the ſulphureous bination; and conſequently, that we cannot admit of *us ſulphur*, of *tartareous ſulphur*, or of others of this re containing vegetable acids, which cannot ever form uly ſulphureous combination, on account of the oil ch enters into their compoſition as an eſſential principle. *the articles* ACID (VITRIOLIC), ACID (VOLATILE PHUREOUS), DETONATION *of* NITRE, LIVER *of* SUL- R, *and* PHLOGISTON.

The uſes of ſulphur are conſiderably extenſive in chemi- , in medicine, and in arts. The liver of ſulphur is



ur is
employed

employed in chemiſtry for ſeveral ſolutions, which may be ſeen at the article LIVER *of* SULPHUR. Sulphur is alſo uſeful for ſeveral fuſions, precipitations, and ſeparations of metals and minerals, as we have already mentioned. Laſtly, as ſulphur contains a very large quantity of vitriolic acid, a method has been found, and is now practiſed, of extracting from it this acid, by burning ſulphur in cloſe veſſels with the addition of ſome nitre, and by an operation ſimilar to that of the clyſſus. *See* CLYSSUS.

Sulphur is employed in medicine, both internally and externally, for aſthmatic diſeaſes of the breaſt, and for ſeveral diſeaſes of the ſkin of the nature of the itch. The internal preparations of ſulphur are, flowers of ſulphur, waſhed ſulphur, magiſtery of ſulphur, tablets, balſams, livers of ſulphur, and others, in ſome of which this ſubſtance is not altered, but only purified and divided, and in others, is combined and aſſociated with other ſubſtances without reckoning the ſulphureous combinations of antimony and of mercury.

Some phyſicians and chemiſts, conſidering that ſulphur is unſoluble in water, and capable of reſiſting the action of moſt menſtruums, have advanced, that it can produce no effect when taken internally, ſingle and unaltered: but this aſſertion ſeems to be without foundation; for we are certain that the ſweat and perſpiration of thoſe who take ſulphur internally have a ſmell evidently ſulphureous. Beſides, ſulphur is much more ſoluble than is generally believed. It is attacked by all oily and ſaponaceous ſubſtances, and conſequently by almoſt all animal liquors.

We cannot eaſily form a very diſtinct and clear idea of the manner in which ſulphur acts internally upon our bodies; but from obſervations made upon its effects, it appears to be dividing, ſtimulating, and ſomewhat heating; it principally acts upon the perſpirable parts of the body, the chief of which are the ſkin and lungs; and from this property, it is particularly uſeful in ſome diſeaſes of those parts.

Sulphur is alſo a powerful repellent, as appears from its curing ſeveral kinds of itch, merely by external applications in form of ointments and pomatums.

Several mineral waters, which are drank, or uſed in baths, for ſome diſeaſes, owe their good qualities to ſulphur contained in them. Such are the waters of Cauterets, Mont D'or, of Aix-la-Chapelle, and of Saint-Amand. Accordingly, theſe waters are employed in ſeveral diſeaſes

reaſt and of the ſkin. Laſtly, ſulphur combined with ſubſtances may contribute to their medicinal powers. *e articles* BALSAM *of* SULPHUR, CINNABAR, ETHIOPS ERAL, MINERAL WATERS, LIVER *of* SULPHUR, MES MINERAL.

lphur is alſo uſed in ſeveral arts. By means of it fine eſſions of engraved ſtones are taken. Matches are ed of it; and its utility as an ingredient in the prepa- n of gun-powder and fire-works is well known. y, it is uſed for whitening wool, ſilk, and many matters expoſed to its vapor during its combuſtion, olors and redneſs of which could not be deſtroyed by other ſubſtance, but are quickly effaced by this acid .

## JLPHUR (GOLDEN) *of* ANTIMONY.

en ſulphur of antimony is a mixture of ſulphur and us of antimony, of an orange color, which is obtained ſſolving the ſcoria of regulus of antimony, and by pre- ating this ſolution by means of an acid.

e may ſee at the article REGULUS *of* ANTIMONY, this ſcoria is a liver of ſulphur, containing a certain tity of the reguline part of antimony. When there- this antimoniated liver of ſulphur is diſſolved in water, when any acid is added to this ſolution, the acid ſeizes the alkali of the liver of ſulphur, by means of which ſulphureous and reguline parts of the antimony were ſuſpended in the water, and at once precipitates both .

though this precipitate be compoſed of ſulphur and us of antimony, as crude antimony alſo is, its proper- re nevertheleſs very different from thoſe of this mineral. precipitate has no metallic color or appearance, and ſides poſſeſſed of a powerful emetic quality, which the nony has not. Theſe differences proceed from the ur of the precipitate not being united with the reguline in the ſame manner, nor ſo intimately, as in crude nony. In the golden ſulphur, the reguline part is only *d* with the ſulphur, and is in a great meaſure diſengaged uncombined; whereas in crude antimony, it is inti- ly connected and united with the ſulphur.

olden ſulphur has ſome reſemblance to kermes mineral: it differs eſſentially in ſome circumſtances, namely, a ſmall portion of fixed alkali remains united with kermes when well prepared, that is, not too much ed, and that the proportion of ſulphur is greater in



kerm.

kermes than in golden ſulphur. To be convinced of th
differences, we need only to attend to the circumſtan
which accompany the precipitation of theſe two ſubſtanc
Kermes is precipitated ſpontaneouſly without addition
any acid, and merely by the cooling of the ſolution of
antimoniated liver of ſulphur which contains it: it is the
fore compoſed of the reguline part, but eſpecially of
ſuperabundant quantity of ſulphur, which the alkali can
keep diſſolved, but by means of a heat almoſt equal to
of boiling water: whereas the ſolutions of antimoni
liver of ſulphur, not only that of kermes itſelf, but
that of the ſcoria of the regulus of antimony which
depoſited its kermes by cooling, contain no more ſulp
than the alkali can keep diſſolved without heat, wh
quantity is therefore leſs than in the kermes. Beſides,
acid neceſſary for the precipitation of the golden ſulp
ſeizes all the alkali; whereas a little of it always adhere
the kermes during its precipitation.

The golden ſulphur of antimony was much emplo
when preparations of antimony were firſt introduced
medicine, but is now pretty much neglected; and ju
becauſe the kermes and emetic tartar produce the ſ
effects more gently and more uniformly. *See* ANTIM
*and* KERMES (MINERAL.)

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TALK. *See* MICA.

TAR. *See* PITCH.

TARTAR. Tartar is a concrete, oily, veget
acid, which is depoſited and is cryſtallized in liquors
have undergone the ſpirituous fermentation. It is a kin
eſſential ſalt of wine.

Probably wines of all kinds depoſite a greater or
quantity of tartar; but the wine of grapes is one of t
which furniſh the moſt of it, and the tartar of this wi
almoſt the only one that is employed or known.

All wines of grapes do not furniſh an equal quantit
tartar. Some of them depoſite it abundantly, and ot
but a ſmall quantity only. Sometimes a longer and ſomet
a ſhorter time is required for the depoſition of ta
Generally a long time is required, and alſo an inſen
kind of fermentation, which continues in the wine a
time after the ſigns of the ſenſible ſpirituous fermenta
have ceaſed. *See* WINE.

artar is depoſited on the ſides of the caſks contain-
. On theſe a hard cruſt is formed, which becomes
d more thick; and as a portion of the fine dregs
ine adheres to this cruſt, the tartar of white wine
greyiſh-white color, and is called *white tartar*;
of red wine has a red color, and is called *red*

, when ſeparated from the caſks on which it is
is mixed with much heterogeneous matter, from
is purified for the purpoſes of medicine and of
. This purification of tartar is performed at
er, and conſiſts (as we find from a Memoir of M.
Profeſſor of Medicine at Montpelier, printed
e Memoirs of the Academy for the year 1725) in
artar in pure water, in filtrating this water, and in
the ſaline matter to depoſite by cold. By this
ration, the groſſer impurities which adhere but
o the tartar are ſeparated: but the cryſtals obtained
peration are ſtill red, and charged with an oily
traneous to the tartar.
this extraneous matter the tartar is purified by boil-
water in which clay is diffuſed. By a ſecond
and cryſtallization, very pure and white cryſtals of
obtained; but they are ſmall and ill-ſhaped, from
kneſs of their formation.
cryſtallization is partly performed by evaporation,
ly by cold. The part which cryſtallizes by evapo-
rms a ſaline cruſt upon the ſurface of the liquor,
*eam of tartar*; and the part which cryſtallizes by
ns ſmall irregular cryſtals, called *cryſtals of tartar*;
name of cream of tartar has prevailed over the
o that it is at preſent applied alſo to cryſtals of tar-
ſignifies in general purified tartar.
of tartar has a taſte ſenſibly acid; it reddens the
ors of vegetables; it may be ſaturated by uniting
of thoſe ſubſtances which are capable of forming
ds neutral ſalts; and it may be afterwards ſepa-
om theſe ſubſtances, and may recover its former
ce. Accordingly, we are certain that this ſaline
an acid. Its property by which it is concrete and
able, it receives from a portion of earth and oil,
ich it is intimately combined, and which approxi-
to the nature of neutral ſalts, eſpecially in what
the cryſtallizable quality and the ſolubility of theſe

Tartar, although acid, is not very ſoluble in water; it even much leſs ſoluble than moſt of the perfectly neut ſalts. According to Mr. Spielman's experiment, an oun of diſtilled water can diſſolve only three grains of cre of tartar, with the heat of fifty degrees of Fahrenhei thermometer, which is equivalent to the tenth degree Mr. Reaumur's. By help of a boiling heat, water diſſol much more tartar; but this tartar cryſtallizes very quic when the water ceaſes to boil. The oily part of the tar ſeems to be the chief cauſe of its difficult ſolubility water.

Tartar is in a great meaſure decompoſed and tota changed by the action of fire. If cream of tartar be diſti ed in a retort with a naked fire, a little phlegm will f riſe with a gentle heat. When the fire is gradually encreaſ which muſt be done very cautiouſly, on account of the p digious quantity of air that is diſengaged during this diſ lation, an acid ariſes in form of white vapors, which accompanied with an oil, at firſt thin, but afterwards m and more colored and empyreumatic. In the retort th remains a coal, ſtrongly alkaline, equal in weight to tw thirds of the tartar employed.

The acid obtained in this diſtillation is indeed oily, therefore retains the character of a vegetable acid; but i very different from the tartar itſelf. It is no longer cryſt lizable; it is only an oily empyreumatic acid, ſimilar to w is obtained from all other vegetables by diſtillation i naked fire. Theſe differences muſt be attributed to portion of oil and of earth, which are ſeparated from t acid by diſtillation. As to the reſiduum of coal, the fi alkali, which it contains ready formed, is remarkable, c ſidering that here there is no incineration in open f which is generally neceſſary for the production of all from almoſt all other vegetables. The cauſe of this ference probably is, that the acid of tartar is almoſt entir changed into fixed alkali, is more diſpoſed to be alkali than any other vegetable acid, whether this diſpoſit proceeds from the quantity of earth and oil which are timately mixed with it, or from ſome change produced u it by fermentation. Mr. Spielman thinks, with m probability, that acids are changed into alkalis by the ſ ſtraction of a part of their aqueous principle: and nature and proportion of the conſtituent parts of ta appear to be very proper to favour this ſubſtraction of

wat

principle by the action of fire. This ſubject is
cure, and would require a more profound exami-

(i)
RTAR EMETIC, *or* STIBIATED
AR. Thus is named the compound formed of
of tartar combined with the metallic part of anti-
when this is half deprived of its phlogiſton. It is
and moſt uſed of all the emetic preparations of anti-
ecauſe the metallic part of this mineral, which gives
tic quality, is in a ſaline ſtate, and is perfectly ſo-
water.

n analyſis of *cream* of *tartar* has been publiſhed by Mr.
the third part of the *Swediſh Tranſ.* for 1770. If pow-
alk be added to a ſolution of cream of tartar in water till
veſcence ceaſes, a copious white ſediment will fall to the
and the liquor will, by evaporation, yield ſoluble tartar.
ves that cream of tartar is not an acid joined with im-
but a compound ſalt containing an alkali with an acid.
te ſediment may be called *tartarous ſelenites*, being cal-
earth united with the ſuperabundant acid of the cream of
f to this ſelenites, dilute vitriolic acid be added, a gypſum
ormed, and the liquor contains a pure acid of tartar. This
, by evaporation, be made to form ſmall white cryſtals,
o not deliquiate. By adding to this acid ſome vegetable
ll the effervescence is over, a tranſparent ſaline fluid will
ned; but if more acid be added, ſmall cryſtals will con-
hich are cream of tartar.
s been generally believed that the alkali of tartar and
vegetable ſubſtances is merely the effect of the combuſtion
d in the preparation of the alkali. But M. Margraaf
s, that it exiſts in ſuch vegetable ſubſtances previous to
mbuſtion, and ſhews that a fixed alkali may be ſeparated
tar by means of acids, without combuſtion. He diſſolved
of cream of tartar in two gros of ſpirit of nitre; and
e ſolution, which was clear and tranſparent, he obtained
of ſalt-petre; and by digeſting, with a very gentle heat,
s of powdered cream of tartar with marine and vitriolic
e obtained a regenerated common ſalt, and a vitriolated
As theſe neutral ſalts are known to conſiſt of their re-
acids united with the vegetable fixed alkali, it is evident
y muſt have received the alkali from the tartar with which
ls were mixed, and conſequently that this alkali exiſts in
le ſubſtances independently of combuſtion. M. Mar-
btained alſo ſalt-petre by adding nitrous acid to ſalt of
erries, and to ſawings of wood.

This

This preparation has been justly substituted for the golden sulphur, for the regulus, for the liver and glass of antimony, and for the powder of Algaroth. It is infinitely preferable to these preparations for the reasons mentioned; but unfortunately, the method of preparing this important remedy has not been fixed and determined. If in fact we consult the several Dispensatories, we shall find very different processes directed: the cream of tartar is employed by all, but some of them require that it should be boiled with the liver of antimony, others with the glass of antimony, and lastly, some with both of these preparations. The proportion also of the ingredients, the length of time of boiling, the method of crystallizing and drying the salt after it has been boiled, are different in different Dispensatories. In whatever manner cream of tartar is treated with the abovementioned preparations of antimony, we always obtain an emetic tartar much preferable to the ancient emetic preparations of antimony. But we are also certain, that the emetic tartars obtained by these several processes are sometimes more and sometimes less emetic; which difference is certainly a great inconvenience in so important a medicinal preparation as this is.

Probably this diversity has been occasioned by persons not considering, or not knowing, that the emetic quality of this preparation proceeds from the metallic earth being dissolved by the acid of tartar, and forming with it a kind of soluble tartar, a true neutral salt, no less capable of a very exact saturation than the vegetable salt, the salt of Seignette, and all the other soluble tartars. For this saturation being a fixed point, and easily to be found, would probably have been universally prescribed, as is done for all other neutral salts, if it had been well known to have occurred in this instance. But as it is now sufficiently ascertained, we may hope that all the faculties of medicine will adopt it, that there may be hereafter only one kind of emetic tartar, always equally strong. Upon this subject we shall add some observations.

First, although regulus of antimony be essentially emetic, it nevertheless produces less effect than the liver or the glass of antimony, because it is less soluble. These two preparations, which are only the metallic earth of antimony deprived of a part of phlogiston necessary to the reguline state, are for that reason more easily soluble by acids than the regulus, and are consequently more emetic. But the glass is still more emetic than the liver, because it has less phlogiston;

Mr. Beaumé affirms from experiment, that this acid may be easily saturated with the reguline part of antimony: and as the glass of antimony is the most emetic and most soluble of all the antimonial preparations made by fire, we ought to prefer it to all other in the preparations of a perfectly neutral antimonial soluble tartar. For this purpose, we must mix together equal parts of cream of tartar and of porphyrised glass of antimony, or rather a larger quantity of the latter ingredient. This mixture is to be thrown gradually into boiling water; and the boiling must be continued gently, till there is no longer any effervescence, and till the cream of tartar be entirely saturated. The liquor is to be filtrated; and upon the filter we may observe a certain quantity of sulphureous matter, together with some undissolved part of the glass of antimony. When the filtrated liquor is cooled, fine crystals will be formed in it, which are a soluble tartar perfectly saturated with glass of antimony. The crystals of this salt have the form of triangular pyramids *(k)*. They are transparent while they are moist; but by exposure to a dry air, they lose a part of the water of their crystallization, and become opake and white.

As the perfect saturation of acids requires constantly a determinate quantity of any substance which they can dissolve, we should be certain, by saturating compleatly cream of tartar with glass of antimony, that the emetic tartar thus prepared would constantly contain the same proportion of emetic antimonial parts. The crystallizing and draining of neutral salts in general, is a good method for obtaining them in their most perfect state: accordingly this salt ought to be first crystallized; but as by exposure to the action of air it is apt to lose some of the water of its crystallization, it ought, immediately after it is crystallized, to be well dried; and then it would remain unchanged. I have frequently administered emetic tartar thus prepared, and I have always observed, that it very well produces an emetic effect when taken from a grain to two and a half, or three, according to the constitution of the patients.

Authors, who have given receipts for the preparation of emetic tartar, have differed, as we have observed, not only

*(k)* The author probably means pyramids, the basis of which is a triangle: for every pyramid must evidently have, at least, four solid angles.

as

e kinds and proportions of the antimonial prepara-
hich they direct to be boiled with cream of tartar,
as to the duration of boiling. Some of them re-
hat the boiling ſhould laſt twelve hours, and others
few inſtants, believing, with Hoffman, that this ſalt
ptible of decompoſition, and of loſing its emetic
by a long-continued boiling. Mr. Beaumé has de-
d this matter by well-conducted experiments, which
at emetic tartar, like other metallic ſalts, is capable
g decompoſed by other metals to which its acid has a
affinity than to the metallic baſis, and that iron, parti-
, is capable of producing this effect upon emetic tartar;
f it be boiled a long time in an iron veſſel, it is actually
oſed, and the liquor is gradually changed into a tar-
tincture of Mars. But Mr. Beaumé alſo found that
tartar may be boiled during any length of time in
made of ſilver or of glaſs, without being decompoſed.
reſults of theſe experiments of Mr. Beaumé are,
t any veſſels ought not to be employed in the pre-
n of emetic tartar; that eſpecially iron, and even
ought to be avoided, for this latter metal is found
act a little upon emetic tartar; and that veſſels of
r of glaſs ought to be uſed. 2. That as the inten-
the operation is to ſaturate perfectly the cream of
the boiling muſt be continued till this ſaturation be
l, which requires a long time when the glaſs of anti-
s groſly pounded, but a much ſhorter time when it is
orphyriſed, as Mr. Beaumé practiſes.
muſt acknowledge that emetic tartar, prepared by
aturating completely the acid of tartar with glaſs of
ny, muſt be infinitely more uniform in its effects,
hat is obtained by any of the other proceſſes hitherto
ed. Nevertheleſs, when we reflect on the nature of
ſs of antimony, we cannot affirm that this emetic
ation, notwithſtanding its perfect ſaturation, muſt
be of equal ſtrength. Glaſs of antimony is made
ng the grey calx of antimony, calcined to a certain
. We know alſo, that if it be too little calcined,
all obtain an opake matter, that reſembles the liver
han the glaſs; but that if it be too much calcined,
not be vitrified, nor even fuſed, by the moſt intenſe
But between the degrees of calcination which is ſuffi-
o give an opake fuſed matter, and the degrees when
ins to be unfuſible, there are many intermediate degrees
cination, all of which are ſufficient to produce glaſſes
of

of antimony; but these glasses differ in degree of transparency, intensity of color, and fusibility, according as the calcination has been more or less compleat. We cannot doubt that different glasses of antimony must be more or less emetic, and that perhaps different quantities of these glasses are required for the perfect saturation of the acid of tartar. Besides, we are not only ignorant of the degree of calcination which renders the glass most emetic; but also, if we did know it, we have no very certain method of attaining it precisely.

Hence, we are not certain that the emetic tartar, prepared by saturating tartar with glass of antimony, has always an uniform and constant emetic power. These considerations have determined me to search, among the several preparations of antimony, for one which should have the same advantages that glass of antimony has, of being convertible into a neutral salt by means of tartar, without the inconveniencies of its uncertain degrees of emetic strength; and I have found that the *powder of Algaroth*, or *mercury of life*, is capable of answering these intentions.

This preparation, which was formerly employed as an emetic, has been justly rejected with the other antimonials that have not a saline quality, because it has the same inconveniencies as these have. It occasioned accidents so terrible, that some physicians have affirmed, that it ought with more propriety to be called the *mercury of death* than the *mercury of life*. But these fatal effects do not prevent the possibility of rendering it a good remedy by a proper preparation; in the same manner as a glass of antimony, which given singly, produced much mischief, has saved many lives since it was converted by its union with tartar into a most efficacious remedy.

Two causes concur in rendering the powder of Algaroth a violent and uncertain remedy. The first is common to it with glass of antimony, and with all the other antimonial preparations that are not saline; and is, its want of solubility in water, for the reasons that we have assigned. The second cause of the violent and uncertain effects of powder of Algaroth is, that a certain quantity of marine acid remains united with it, and communicates to it a certain degree of caustic quality. But both these causes of the bad effects of this preparation may be easily and certainly removed. For, by washing it with a little fixed alkali, all the acid may be separated. And I have found from experiments, that the powder thus washed is altogether soluble by

o of tartar, and of being thereby convertible into
e emetic tartar, perfectly neutral; for which, pur-
thing more is required than to boil it, and saturate
cream of tartar, and to treat it in the manner
irected for the preparation of emetic tartar with
antimony. We may easily perceive that powder
roth thus prepared, is a calx of antimony constant-
he same degree of emetic strength. It is emetic,
the regulus of antimony first dissolved by marine
d afterwards separated from that acid, retains the
of phlogiston that is necessary to give an emetic
to the calx of antimony: but the quantity of phlo-
which it retains, and therefore its emetic power,
ays be the same: for the marine acid of the corro-
imate, which afterwards becomes the acid of the
f antimony, is always the same in quantity, and
grees of concentration and of activity: consequently
of antimony separated from it must always contain
l quantity of phlogiston; and is therefore much
le to glass of antimony, which contains sometimes
d sometimes less phlogiston.

ubstituting therefore powder of Algaroth to glass
nony, and by treating it in the manner above-men-
we may obtain the most uniform and certain emetic
at can be prepared: physicians, who must be sen-
the advantage of such a remedy, need not be
concerning its degree of strength. If it were once
they would have occasion only to attend to the
ty or irritability of the constitutions of their pa-
*See the articles* ANTIMONY, POWDER *of* ALGAROTH,
*of* ANTIMONY, *and also all the other preparations of*
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RTAR (VITRIOLATED). Vitriolated tartar
tral salt composed of a vitriolic acid saturated with
d alkali of tartar, or with any other pure vegetable
kali.

salt is prepared by pouring vitriolic acid into a solu-
vegetable alkali, till no more effervescence appears,
he liquor becomes perfectly neutral, which may be
by the ordinary trial of syrup of violets. From
uor, filtrated and evaporated, small crystals are ob-
each of which has many sides, sometimes more,
netimes fewer; for the crystallization of this salt
uch in this respect. It is, in general, one of those
e form of whose crystals is the least constant. The
greatest

greateſt number of the cryſtals of this ſalt appear to have been cubes, the angles of which have been cut off.

Vitriolated tartar is one of the ſalts which cryſtallize better by evaporation than by cold. It requires a large quantity of water to diſſolve it. According to Mr. Spielman's experiments, thirty grains only of this ſalt are ſoluble in an ounce of water with a heat marked by ten degrees above 0 in the ſcale of Mr. Reaumur's thermometer. Its taſte is moderately ſaline, and ſomewhat diſagreeable, but not acrid nor ſharp. It decrepitates, when heated ſuddenly and ſtrongly. It contains a ſmall quantity only of the water of cryſtallization, by means of which it cannot be liquefied; neither can it be fuſed but by a very intenſe heat.

As vitriolic acid has a greater affinity with the fixed alkaline baſis of the vitriolated tartar than with any other ſubſtance, excepting phlogiſton, and as this alkali has a ſtronger affinity with this than with any other acids, hence vitriolated tartar cannot be decompoſed but by means of the inflammable principle, as in the proceſs for making artificial ſulphur. Mr. Beaumé has indeed diſcovered, that vitriolated tartar may be decompoſed in the humid way by nitrous acid alone, which diſengages the vitriolic acid, and forms nitre with its alkali. But if we examine well all the circumſtances of this phenomenon, we ſhall find that this is no exception to the general rules concerning affinities, and that phlogiſton is the principal agent in this ſingular decompoſition, as Mr. Beaumé has ſhewn in the explication that he has given of it. *(l)*

Vitriolated

*(l)* Vitriolated tartar may be decompoſed by nitrous acid in the following manner, according to Mr. Beaumé. Equal parts of vitriolated tartar and nitrous acid are put into a matraſs and heated till the ſalt be diſſolved. From the liquor, when cold, true cryſtals of nitre may be obtained. Mr. Beaumé believes that this decompoſition is effected by means of the greater affinity of the nitrous than of the vitriolic acid to the phlogiſton, which, he ſuppoſes, enters into the compoſition of the vitriolated tartar: and he thinks that the reaſon why this decompoſition does not happen in the dry way, or by fuſion, as well as in the humid way or by cold ſolution, is, that the nitrous acid is in the former caſe diſſipated by the action of the fire. This ſingular fact, which ſeems to contradict a general opinion, namely that vitriolic acid is more diſpoſed than nitrous acid to unite with fixed alkali, is alſo confirmed by the intelligent and accurate

ated tartar may alſo be decompoſed by means of a
finity, when it is mixed with ſolutions of certain
acids. But as by phlogiſton only metals are diſ-
acids, we need not doubt that this principle has
influence in theſe decompoſitions.

vitriolic acid has a greater affinity than any other
fixed alkali, we may therefore make vitriolated
applying that acid to any neutral ſalt compoſed of
nd a fixed alkali, as in the decompoſition of nitre;
fixed alkali has a greater affinity with vitriolic
any other ſubſtance, vitriolated tartar may be
made by applying a fixed alkali to any vitriolic
lt, the baſis of which is not fixed alkali. Ac-
, all vitriolic ſalts with baſes of volatile alkali,
ous, argillaceous, or metallic earths, may be de-
by fixed alkalis; and the compound formed by
ompoſitions will always be a vitriolated tartar,
of the fixed alkali employed in the operation,
e vitriolic acid of the decompoſed neutral ſalt.
may perceive, that vitriolated tartar is made in
mical operations.

the theory of theſe operations was underſtood,
e the fixed vegetable alkali was known to be the
whatever vegetable it was obtained, the ſeveral
tartars formed in different operations, and with
alkalis obtained from different vegetables, were
be different kinds of ſalts, and were diſtinguiſhed
nt names; as the *ſal de duobus*, *ſal polychreſt of*
*canum duplicatum*. But we conſider all theſe ſalts
e vitriolated tartar, with which the other names
mous.

lt is not of any uſe in the arts, and is but little
emiſtry. It is principally employed in medicine.
other neutral ſalts with baſes of fixed alkali, it
e in ſmall doſes, as a gros [72 grains]; and it is
when taken from ſix gros to twelve. The vitrio-
r which is prepared by decompoſing nitre with
cid called *ſal de duobus*, has been much celebrated

r. Margraaf, who further affirms, that in the ſame
treatment, vitriolated tartar, Glauber's ſalt, and
be decompoſed by marine acid. As marine acid is
t more diſpoſed to unite with phlogiſton than nitrous
c acids are, Mr. Beaumé's explanation of this ſingu-
oſition does not ſeem to be ſatisfactory.

as a remedy against the effects proceeding from an extrava-
sation of a milky humour, for which disease it has bee
considered as the best resolvent and evacuant. Neverthele
as Mr. Baron well observes in his Notes on Lemery, n
reason can be given for preferring this salt to other neutr
salts. On the contrary, as it is one of those which a
most perfectly saturated, its action and qualities must be le
effectual than most of these. *See the articles* ACID (V
TRIOLIC); ALKALI (FIXED VEGETABLE); CRYSTALL
ZATION; *and* SALT.

TERRA FOLIATA TARTARI; FOLIATE
EARTH *of* TARTAR. This name has been given impro
perly, and merely for the sake of some earthy appearanc
to a *neutral acetous salt with basis of vegetable fixed alkali*,
to a combination of the acid of vinegar, saturated with th
alkali of tartar or of other vegetable matters. This s
has also been called *regenerated tartar*, although it really
very different from true tartar, but only because the alka
of tartar is united with an acid, which in some respects
similar to the acid of tartar, but in others is very di
ferent, as may be seen at the articles TARTAR *and* VINE
GAR.

The terra foliata is made, according to most dispensa
tories, by pouring upon a quantity of alkaline salt of tarta
in a glass-cucurbit, a sufficient quantity of good distille
vinegar, at different times, to saturate all the alkali,
even a little more than is necessary for that purpose, an
till the effervescence entirely ceases. This saturated liqu
is to be filtrated, and evaporated to dryness, with a gent
heat. The dry salt thus obtained is to be dissolved in spir
of wine, and the solution is to be again evaporated to dry
ness; by which means a salt is obtained more or less whit
of a silky appearance, and composed of small scales
leaves, from which it has been called *foliated*. When th
salt is dried, and while it is yet hot, it must be shut up in
well closed bottle, because it quickly becomes moist b
exposure to air.

When distilled vinegar is poured upon salt of tarta
little or no effervescence is made at first; but afterward
when more vinegar is added, the effervescence becom
so considerable, that some of the liquor will flow over th
vessel, if care be not taken. This effervescence is produce
by a large quantity of air that is disengaged during th
saturation. Accordingly the vapor extricated during th
effervescence is very *aerial*, and so pungent, that if it b
confine

ome time in a close vessel, and then set at liberty, rritating and suffocating as volatile alkali, or lphureous acid, although it be really different er of these: for this vapor is nothing but r similar to the *gas* of spirituous mineral wa-

the saturation is advanced to a certain degree, escence diminishes, and even ceases entirely, ne saturation be not yet compleated; the reason is, that the last portions of acid and of alkali y readily combine. The combination may be by frequently agitating the liquor, by which effervescence may be again renewed. When cannot by agitation be made to effervesce more, then allowed to stand during some time, as Mr. actises. This chemist, and very excellent ob- remarked, that the mixture deposites a certain earthy matter proceeding from the fixed alkali, must be necessarily separated by filtration, to ry white foliated earth of tartar. He has also hat when the alkali employed is very pure, and the mixture of neutral salts, the saline matter by the process has no foliated or crystallized

already remarked, that foliated earth of tartar is ent salt. This quality proceeds from the weak- union of the acid with the alkali; the cause of nt union is, that some oily and spirituous prin- nited with the acid in vinegar. The taste of the rth is sharp, pungent, almost a little caustic,

vapor which causes the effervescence in the pre- this salt, is the gas that is disengaged from all mild stances by means of any acid; and the humid part r is nothing more than some particles of the effer- or, which are forcibly thrown upwards by the rising hich form a small jet or shower above the surface rvescing liquor. *See* Gas. The reason that this does not begin immediately upon pouring on the that a part of the alkaline salt employed is generally deprived of its gas, which part unites with the ably to the mild part of the alkali, and absorbs t is extricated from this latter part: and therefore austic part of the alkali be nearly saturated, little or ence can happen.

and partaking at the same time of the taste of vineg and that of fixed alkali. This salt is one of those that a soluble in spirit of wine. It may be decomposed merely b the action of fire; and from it, as from any other aceto salt, may be obtained by distillation, a radical vinegar, ve penetrating and very concentrated.

Foliated earth of tartar is little used but in medicine. is considered as a powerful resolvent and aperitive; and probably possesses these qualites, merely as it retains som of the action of the acid and of the alkali, of which it composed. Its dose is from fifteen or twenty to thirty-f grains, or even more, when no irritation is apprehende *See the articles* ALKALI (FIXED); SALT; SALTS (NE TRAL); *and* VINEGAR.

TERRA JAPONICA. *See* JAPONIC EARTH.

TEST, *and* TESTING. *(n)*

TIN. Tin is a metal, the color of which resembl that of silver, but is darker and less white. It is soft less elastic, and less sonorous than any other metal, excep ing lead.

When it is bent backwards and forwards, it occasions crackling sound, as if it was torn asunder.

Tin has, like other imperfect metals, a smell and a tas

It is much less ductile than some harder metals; althou it may be beat into very thin leaves.

The tenacity of the parts of tin is not very considerabl since a wire of this metal, the diameter of which is $\frac{1}{10}$ an inch, can support a weight of 49½ pounds only.

It is the lightest of all metals, as it loses only $\frac{1}{7}$th part its weight when immersed in water. It is very fusibl and requires for this purpose a heat much less than is suf cient to make it red-hot.

With the heat necessary for its fusion it may also be ca cined, or at least deprived of so much of its phlogisto that it appears in form of a grey calx, which cann be reduced entirely to tin without the addition of some i flammable matter.

Workmen call this imperfect calx of tin, *ashes of ti* and those who travel in the country, casting tin spoon call it *dress of tin*. This they carefully skim off, preten

*(n)* TEST *and* TESTING. A test is a large kind of cu used in operations for refining large quantities of gold and sil by means of lead; and the operation is called *Testing*. S CUPEL; CUPELLATION; *and* REFINING.

in

by to purify their tin. But they preſerve this drofs, and reduce it to tin by melting it with ſome

aſhes of tin, like other calxes of metals, may be eprived of phlogiſton, by a calcination continued ore intenſe fire, by which means it becomes more white, hard and refractory. It is then called l is uſed in the arts for poliſhing glaſs and other es.

f tin, very white and well calcined, is a very re- ſubſtance. Its beautiful whiteneſs and refractory nder it capable of forming, together with ſome d vitrifiable matters, a white enamel, which is white glazing or covering for delf-ware. *See* ARE.

oſt ordinary method of preparing this putty, is by gether lead and tin, and expoſing this mixture to a at. Theſe two metals have been found to be ly calcinable when mixed than when ſingle. By the calx thus obtained ſome ſand and vitrifiable by fuſing the mixture, a very beautiful white ay be made: for lead does not, like tin, loſe its ality by calcination.

expoſed very pure tin, ſingly, to a fire as ſtrong a glaſs-houſe, during two hours, under a muffle, covered teſt; and having then examined it, I covered with an exceeding white calx, which to have formed a vegetation; and under this reddiſh calx, and a tranſparent hyacinthine glaſs; , at the bottom, a piece of tin unaltered. This nt was ſeveral times repeated with the ſame ſuc-

mixed with tin may be inflamed, and it haſtens ply the calcination of this, as it does of other im- etals. The vapors which riſe during the ſeveral ns of this metal have generally an alliaceous or ſmell; becauſe tin generally contains ſome arſenic, argraaf has obſerved.

gh tin be one of the moſt calcinable metals by fire, it is much leſs apt to ruſt by the combined air and water, than iron and copper. Its ſur- it is clean and ſhining, loſes indeed its luſtre, ſhes quickly by expoſure to air, but the ſlight kind hich is there formed remains thin and ſuperficial,

and does not advance so deeply into the substance of th metal as the rust of iron and of copper generally does. Hence tin is advantageously employed to cover many utensils mad of these metals. *See* TINNING.

Every acid is capable of attacking or dissolving tin.

Vitriolic acid requires to be assisted by a certain degree o heat to dissolve tin efficaciously. I have observed, tha during this solution sulphureous vapors are raised; and have even separated some black particles, which I hav found to be true inflammable sulphur. The production o extraction of this sulphur requires a particular examination *See* SULPHUR.

Nitrous acid attacks tin with very great violence, especiall when the metal is much divided. But when the acid is ver pure, it rather corrodes and calcines, than dissolves tin As the phlogiston of this metal is not very strictly engaged the nitrous acid chiefly attacks it by means of this prin ciple, which it seizes, and separates from the tin, that thus reduced to an unsoluble white earth, or calx, de posited at the bottom of the acid. This calx of ti made by nitrous acid appears to be as perfectly dephlo gisticated, as that which had been exposed during a lon time to fire. I have attempted unsuccessfully to reduce to its metallic state. This calx makes a very good whi enamel.

The acid of common salt dissolves tin perfectly well b help of heat. I have observed, that when I put a consider able quantity of fine granulated tin into a matrass, an poured some smoking, and consequently colored, spirit o salt upon it, that the acid quickly ceased to smoke, an lost its color; that it attacked the tin with a sensible bu moderate effervescence, and became saturated with i This acid dissolved more than half its weight of tin. Th vapors which rose during the solution had a disagreeab arsenical smell; and the solution when saturated was clea and colorless as water. Having kept the solution in a bottl I observed that, during the winter, it almost all crystallized and that the crystals became fluid during summer. Som years afterwards a white sediment was formed in this solu tion.

Tin has a greater affinity with marine acid than som othe metallic substances which have also much affinit with this acid; for it separates the marine acid from lun corn a, from corrosive sublimate, and from butter of ant mony. When tin is mixed, especially with corrosive sub limate

decompoſes this ſalt, even without heat; and
re produced becomes moiſt by expoſure to air.
iſtilled before it has imbibed much moiſture, a
ing ſpirit of ſalt, called *ſmoking ſpirit of Liba-*
obtained. *See* SPIRIT (SMOKING) *of* LIBA-

cid retains much tin diſſolved, ſome of which it
g with it in diſtillation, as it does ſeveral other
atters. Accordingly, in this diſtillation, a con-
ine, metallic matter is ſublimed, that may be
*er of tin:* which name has been given by ſome
o the ſmoking ſpirit.
he detail we have given of the ſolutions of tin by
d marine acids we may perceive, that the former
ves it of all its inflammable principle, but has
upon its dephlogiſticated earth; and that the
the marine acid upon this metal are quite the
Accordingly, when theſe two acids are united
forming an aqua-regia, they compoſe a men-
which acts very efficaciouſly upon tin, on account
tivity of the nitrous acid, but which does not
e metal, as nitrous acid ſingly does, becauſe the
this acid is moderated by the marine acid: hence,
nitrous acid is contained in aqua-regia, the
lar are its effects upon tin to thoſe produced by
cid alone; and reciprocally with regard to marine

ſolution may be made of tin in aqua-regia, if
be given to the following particulars. A ſmall
nly of tin ought to be put into the acid, and no
d till the firſt piece be entirely diſſolved; becauſe
ch tin is added at once, the heat occaſioned by
on encreaſes the activity of the ſolvent ſo much,
n is as much calcined and precipitated as if pure
id had been employed; but when the tin is added
and the heat is thus reſtrained, the aqua-regia
charged with this metal, that it ſhall be thick
, like a liquid tranſparent reſin. The ſolution
ed has a yellow-reddiſh color.
y obſerve, that in this ſolution there is a conſi-
antity of tin upon which the nitrous acid of the
has not exhauſted all its action, although this
n ſeems to be more than ſaturated; for I have
that when this liquor is heated, an effervescence

 happens

happens entirely similar to that which is occasioned during the solution of metals by acids. This effervescence lasts till the parts of the tin which were only half dissolved have been redissolved a second time; after which the solution is found to have lost its color. Sometimes this solution becomes quite fixed or solid when it cools, and appears like a firm jelly, and transparent as crystal.

All the solutions of tin are acid and corrosive; and may be decomposed by being diluted with much water; in which case, the tin is copiously precipitated in form of a white calx.

When a solution of tin is mixed with a saturated solution of gold, and when the mixture is diluted with a large quantity of water, a purple precipitate is formed, called *purple powder of Cassius. See that word.* This powder is employed for painting on enamels and on porcelain.

The solution of tin in aqua-regia, added to the tinctures of cochineal, of gum-lac, and of some other red tinctures, heightens the color of these, and changes it from a crimson or purple to a vivid reddish-yellow or fire-colored scarlet. Dyers call this solution of tin, with which they give a scarlet tinge, *the composition.* We may observe, that this color succeeds only with wool and other animal matters. Attempts have been made, but without success, to give this color to thread, to cotton, or even to silk, although this latter substance has many properties of animal matters.

I have also observed, that the larger quantity of nitrous acid is contained in the aqua-regia, which dissolves the tin, the nearer does the red color communicated to cochineal approach to the vivid yellow, so that the solution of tin made with marine acid alone, or with vitriolic acid, does only give to red tinctures a crimson color, as alum does. *See* DYING.

Vegetable acids, as vinegar and cream of tartar, are also capable of dissolving tin: but the properties of these solutions have not yet been well examined.

Tin, according to Mr. Geoffroy's Table of Affinities, has a stronger affinity with the acid of common salt than regulus of antimony, copper, silver, and mercury; because the combinations of this acid with these metals are decomposed by tin, which precipitates them, and unites with the acid.

Sulphur may be united with tin by fusion, and forms with it a brittle mass, more difficultly fusible than pure tin.

Sulphur

has in this respect the same effect upon tin as upon
'he allay of sulphur lessens the fusibility of these
ble metals, while it encreases the fusibility of other
y fusible metals, as of iron and copper.
nay be allayed with all metals by fusion, and in all
ons; but it absolutely destroys their ductility. A
ble circumstance is, that the most ductile metals, as
d silver, are those the ductility of which is most
y tin. The vapor of a single grain of tin is capable
ring a considerable quantity of gold brittle. The
of copper is less injured by tin than that of other
although it is considerably injured. A singular
ance concerning this allay is, that tin, although a
: metal, and not at all sonorous, augments con-
the stiffness, the hardness, and the sonorousness
r, as we see in *bell-metal.*
llay, or amalgam of tin with mercury, is employed
one of the surfaces of looking-glasses, by which
e rendered capable of reflecting the rays of light,
forming mirrors. This covering of tin and mer-
hich is applied upon glasses, is called *tinning.*
allayed with an equal quantity of lead, forms the
sed by plumbers.
rding to Mr. Gellert's Table, the affinities of tin
n, copper, silver, and gold. *See, for the allays of*
*words* ALLAY, AMALGAM, *and* BRONZE.
is not much used in medicine, and for good reasons:
find, from a long Dissertation by Margraaf upon
tal, that tin generally contains more or less of an
l matter, which probably proceeds from the ores of
all these contain arsenic. *See* ORES *and* SMELTING
s. Mr. Margraaf discovered this arsenical part of
efly in the humid way, and by solution in acids.
hite calx of this metal is commonly employed in the
tion of the *antihectic* of *Poterius*, and of the *lilly of*
*sus:* but this calx is unsoluble and ineffectual: be-
t appears to furnish no part of the lilly.
is very extensively useful in many arts, as we may
rom what has been said of the different preparations
metal.
NNING *of* COPPER, *and of* IRON. Tin-
an operation by which a very thin layer of tin is
to the surface of some metals, and especially of
and of iron. The methods of tinning these two
are different. Copper is tinned after it has been
formed

formed into utenſils, and by the copper-ſmiths who form theſe utenſils. The tinning of iron is performed upon thin plates of iron, in particular manufactories in France, in Germany, and in ſome other places. Workmen, called *tin-ſmiths*, do only form theſe plates, which are brought ready made from their proper manufactories, into the various utenſils required.

The ſeveral operations for tinning of copper and iron are founded, firſt, on the facility with which tin unites with theſe metals, which is ſo great, that when either of theſe metals are tinned, the tin only requires to be melted, and the others on which it is to be applied do not. Nevertheleſs, the tin incorporates with theſe metals, diſſolves in ſome meaſure their ſurface, and forms a kind of allay, at leaſt when the tinning is well performed.

Secondly, the foundation of all the parts of the operation uſed to make the tinning ſucceed is, that metals cannot perfectly unite with each other but when they are in a metallic ſtate; and that they cannot unite with any earthy matter, not even with their own earth or calxes.

Hence, the whole art of tinning conſiſts in applying melted tin, the ſurface of which ſhall be very clean, metallic, and not covered with any aſhes or calx of tin, to the ſurface of iron or of copper, which muſt alſo be very clean, and free from all ruſt or calx.

To attain theſe purpoſes, the following method is uſed. As the ſurface of copper is continually altered merely by the action of air, the workmen, before the tinning of any veſſel, ſcrape its ſurface with a ſteel inſtrument till it be clean and bright: then they place the veſſel upon kindled coals, and heat it to a certain degree: as ſoon as it is hot, they rub it with pitch; and then apply the melted tin, which they ſpread upon the ſurface of the copper by means of hards. Pure tin is ſeldom uſed for this purpoſe; but generally two parts of tin are allayed with one part of lead.

The pitch uſed in this operation is quite neceſſary, becauſe the degree of heat given to the copper is ſufficient to calcine its ſurface in ſome meaſure; and this alteration, however ſlight, would prevent the perfect adheſion of the tin, unleſs, by means of the pitch, the phlogiſton was reſtored to it at the very inſtant of the application of the tin. This pitch prevents alſo the ſlight calcination which would happen on the ſurface of the tin, or revives the

l particles of calx which are formed during the

plates of iron are to be tinned, they muſt be per-
ll cleanſed, which is done by ſcouring them with
l ſteeping them ſome time in acid liquors: then
to be wiped, and dried quickly and perfectly.
hey are to be plunged vertically into a veſſel con-
nelted tin, the ſurface of which is covered with
itch. Theſe fat ſubſtances covering the ſurface of
ſupply it continually with phlogiſton, prevents its
on, by which its adheſion to the iron would be im-
nd alſo render the ſurface of the iron, while it paſſes
them, fitter to receive the tin. By thus plunging
iron into melted tin, they are covered over with
l, or are tinned.

moniac is alſo uſed ſucceſsfully in the tinning of
of copper, and always for the ſame reaſon. The
his ſalt perfectly cleans the ſurface of the metals to
l, and alſo the oily matter contained in ſal ammo-
iſhes the phlogiſton that is neceſſary in this opera-
hus, by heating theſe metals to a certain degree,
ing them with ſal ammoniac, the tin may be ap-
nediately afterwards.

dvantages received from tinning are very conſider-
s tin is a ſoft and fuſible metal, veſſels formed of
would not have ſufficient ſtrength and hardneſs
heir ſhape in common uſe, and would alſo be liable
elted with a ſmall heat: but when it is applied to
ce of hard and difficultly fuſible metals as copper
, many veſſels may be fabricated, which have
ntage of being preſerved by means of the tin
t, to which the copper and iron are very ſubject.
een, nevertheleſs, juſtly alledged, that copper
re not perfectly prevented from ruſt or verdigriſe
g; and this fault is ſo much more important, as
opper veſſels, are generally uſed in the preparation
als. Theſe veſſels therefore, even when tinned,
ot to be employed for this purpoſe; eſpecially as
is ſuſpected of being hurtful to health, ſince Mr.
f diſcovered that arſenic is contained in almoſt all
alſo becauſe lead, a moſt hurtful metal, is uſed
ng. Nevertheleſs, tinned copper veſſels may be
many other purpoſes. Beſides, the tinning of
nd iron veſſels may be improved, by attending to
the

the fundamental principles of this art delivered in the prese article. (o)

TINNING *of* LOOKING-GLASSES. Thi operation consists in applying an amalgam of tin and mer cury upon one of the surfaces of looking-glasses, by whic they are rendered much more capable of reflecting the ray of light, and consequently of representing, in a clear an lively manner, the images of objects.

This effect of the tinning of looking-glasses is founde on the superior opacity, and consequently on the superio reflective power of metallic to all other substances.

Glasses to be tinned are placed upon tables in a perfectl horizontal or level situation. The surface, previously wel cleaned, is to be covered with tin-leaves, which also mus be very clean. Upon these is poured a sufficient quantit of mercury to cover the whole surface, and it is allowed t rest some time, that it may amalgamate perfectly with th tin-leaves: then a small degree of inclination is given t the glass, that the superfluous mercury may run off; whic inclination must be gradually encreased till the glass be a last brought to a vertical situation, by which means no mor mercury remains than is really amalgamated with the tin As the surface of the glass is exceedingly smooth and wel polished, the amalgam is in very perfect contact with it and therefore firmly adheres to it.

The success of this operation depends much on the clean ness of the surface of the glass; for the least dirt or dus interposed betwixt the amalgam and the surface of the glass would absolutely prevent the adhesion of contact betwee these two bodies.

Since vitrified matters, as glasses are, cannot unite in timately with metallic substances, the adhesion of the amal gam upon the glasses is not so strong as that of metals upo metals; as in the tinning of copper and of iron, in whic there is a solution, a penetration, and an intimate unio of the tin with the surface of the tinned metal: but in th

(o) M. Malouin has proposed, in his Memoirs on Zinc, (Mem. de l'Acad. des Sciences, 1742) to substitute that semi-metal in place of lead and tin, for the tinning of iron and copper vessels: The greater hardness of the zinc, it is thought, would render it les liable to be worn, and the dangerous effects of lead and tin woul be avoided. But whether it might not be attended with othe inconveniences, must be submitted to further experience. *Disc prel. Mem. Acad. Berlin* I.

of looking-glasses, there is only the adhesion of or a perfect juxtaposition, which may take place any bodies, however heterogeneous, by the appli- their polished surfaces. Accordingly, this me- vering may very easily be taken off, and ought to ved from moisture, and from any kind of rubbing, slight. For which reason, the superfluous mercury made to run off very gently and slowly, otherwise nalgam might fall off by its weight.

CAL. *(p)*

CTURE. By this name are distinguished, in and pharmacy, all spirituous liquors that are y being digested upon different substances. These erly speaking, infusions in ardent spirits.

chemical preparations are called *tinctures*. We t of some of the chief of these.

CTURE (ALKALINE). *See* TINCTURE *of* TARTAR.

CTURE *of* ANTIMONY. This tincture according to the Paris Dispensatory, in the follow- ner: Let a mixture of one part of crude antimony, parts of the alkaline salt of tartar, be fused in a crucible, and the fusion continued during an The melted matter is to be poured out; and as t has become solid, it is to be pulverised; while yet s to be put into a matrass; and upon this powder spririt of wine is to be poured, to a height above der equal to the breadth of three fingers. This is to be digested with a gentle heat during several which it acquires a deep red color; and then e decanted and preserved in a well-closed bottle.

s fusion of crude antimony with fixed alkali, a sulphur is formed, which dissolves the reguline antimony. It is consequently an antimoniated sulphur, nearly of the same nature as that of which *ineral* is made: but in the present operation this s not dissolved in water, but is digested in spirit

INCAL. Borax, in the crude state in which it is brought a, and before it is refined, is called tincal. It consists crystals, of a yellowish color, and it has a greasy or touch. According to Mr. Cadet, it contains a larger of the peculiar vitrescible earth of borax, than the re- commonly sold does. *See* BORAX, *and* SALT (SEDA-

of

of wine; which menſtruum ſeems to diſſolve a part of the whole matter, that is, a part of the liver of ſulphur, and by means of it alſo ſome of the regulus of antimony; for this tincture acquires a red color, and produces nauſea according to Lemery, when taken internally. According to the ſame author, the doſe of this tincture is from four drops to twenty, and is to be adminiſtered in ſome proper liquor.

The medicinal effects of this preparation may be very good, and analogous to thoſe of kermes; but it is not much uſed. *See* KERMES (MINERAL).

This ſolubility of antimoniated liver of ſulphur in ſpirit of wine is remarkable: but an explanation of all the appearances that occur in this and in ſeveral other operations would require more particular reſearches than have yet been made.

TINCTURE *of* MARS. Iron, being a metal much employed in medicine, has been prepared in various manners for internal uſe. Amongſt the principal of theſe are the following tinctures.

TINCTURE *of* MARS (LUDOVICUS'S). This tincture is made, according to the Paris Diſpenſatory in the following manner: Four ounces of martial vitriol calcined to whiteneſs are to be mixed with an equal quantity of cream of tartar, and this mixture is to be boiled in a pound and a half of water, till the whole has acquired the conſiſtence of honey. This maſs is to be put into a matraſs, into which ſome rectified ſpirit of wine is to be poured to a height equal to the breadth of four fingers. After a digeſtion during ſome time in a ſand-bath the tincture is to be decanted, and a freſh ſpirit of wine is to be poured on the reſiduum, and digeſted as before. Theſe operations are to be continued as long as the ſpirit of wine acquires color: and, laſtly, all theſe tinctures are to be mixed together and preſerved for uſe.

The theory of this proceſs is not well known; becauſe all the circumſtances have not been examined with ſufficient attention. We ſee, indeed, that the cream of tartar ought to act upon the portion of the iron of the martial vitriol, which does not adhere very ſtrongly to the vitriolic acid, or which is even quite diſengaged from that acid by calcination; and that this combination of iron with cream of tartar may be ſoluble in ſpirit of wine, to which it may communicate color, and conſequently may form the preſent tincture: but does not the cream of tartar act alſo

upon

iron which is united with the vitriolic acid; and
s not act, does the martial vitriol diſſolve in ſpirit

oes not diſſolve in this ſpirit, when it is ſingle and
inary ſtate, and charged with much iron, may it
ne ſoluble either when it has depoſited a part of
or by means of the acid of tartar? Theſe are
which, I believe, have not been yet examined;
h muſt be aſcertained, before we can know pre-
nature of this tincture of Mars. For its medi-
ues, *ſee the article* IRON.

CTURE *of* MARS *of* MYNSICHT. This
is made by digeſting the martial flowers of ſal
: with a ſufficient quantity of rectified ſpirit of
matraſs.

of wine diſſolves the ſalt formed by the union of
n the acid of ſal ammoniac; but as this ſpirit can
lve the ſal ammoniac itſelf, it may be charged
rtain quantity of the latter ſalt in this operation:
n very poſſible, that by means of this ſal ammo-
liſſolves a greater quantity of the martial ſalt than
otherwiſe do; and reciprocally, that the martial
it in a condition of diſſolving a greater quantity
nmoniac; which effects are ſimilar to thoſe pro-
treating in the ſame manner corroſive ſublimate
mmoniac in ſpirit of wine: but I do not believe
reſearches have been made to elucidate this ſub-
hemiſts, who have given receipts for moſt of the
l preparations of this kind of which we now treat,
quently capricious mixtures, the effects of which
not know. Theſe preparations have been con-
by uſe, although little trouble has been taken to
their nature: but now that chemiſtry, taken in
nd genuine ſpirit, has become a ſcience as accurate
ous in ſome meaſure as geometry, all theſe ancient
ought to be ſcrupulouſly examined. We ſhould
tainly reject many of theſe for their unfitneſs to
the effects expected, and we ſhould know better
es of thoſe which ſhould be judged worthy to be
in uſe. Probably the tincture of Mars of Myn-
ſeſſes the medicinal qualities of iron diſſolved by
cid, and of ſal ammoniac.

CTURE *of* MARS (ALKALINE) *of*
L. This preparation, the knowledge of which
s communicated to us, is a ſolution of iron in fixed
alkali.

alkali. Although this saline substance be capable of acti directly upon iron, and of dissolving it in some measu this combination succeeds much better when the iron be united with the alkali is previously divided by being d solved in an acid, and especially in nitrous acid, as Sta has shewn.

According to the process of this celebrated chemist, t iron ought to be previously dissolved in nitrous acid, a the solution ought to be as perfectly saturated as possib This saturated solution is to be added at several differe times to a strong solution of vegetable fixed alkali. Ea time that the solution of iron is poured into the alkali liquor, a kind of precipitate or coagulum of a deep r saffron color is instantly formed: but this precipitate d appears soon after, and dissolves entirely in the alkali liquor, to which it communicates a deep-red yellowish colo More of the solution of iron is to be poured into the alk line liquor, till the precipitate is no longer redissolve Lastly, this solution, which is the martial alkaline tin ture of Stahl, is to be filtrated.

We may easily conceive what passes in this process. T alkali, into which the combination of iron with nitro acid is poured, decomposes at first this combination, uniting with the acid, and precipitating the iron. But there is much more alkali than is required to saturate t quantity of acid added, the uncombined portion of alka finding the iron in a very divided state, attacks and di solves it perfectly.

Iron is not the only metal that may be thus dissolved an alkali. Almost every metal is more or less soluble alkalis, as Mr. Margraaf has shewn. *See his Opuscul Chemiques Diss.* III. This celebrated chemist found that n very pure alkalis, but alkalis phlogisticated by calcinati with ox's blood and volatile alkali, were fit for this purpo

This solution of iron in fixed alkali does not always su ceed, and even sometimes fails, when all the circumstanc directed by Stahl have been observed. I have remarke and also Mr. Beaumé, that it succeeds much more co stantly, and almost certainly, when a solution of iron n nearly saturated and very acid is employed; and when t solution has not the reddish-yellow color of rust that sat rated solutions have, but is clear and limpid, or only sligh ly greenish. We were induced to believe, that a sim lar excess of acid was favourable for redissolving other m tallic precipitates from their acid menstruum by means

alkal

d even that with this excefs, the operation can-
d. But Mr. Marges, an inteliigent chemift, has
a folution of iron much impregnated, and high
he iron of which might be perfectly diffolved by
li, without heat; and which conftantly formed
l alkaline tincture, either by pouring the folution
ali, or the alkali to the folution; which proves
henomenon depends on the concurrence of feve-
ftances; as on the ftate of the iron in the ni-
, which is known to be very variable; on the
lefs phlogiftication of the alkali; and perhaps
everal other circumftances, which ought to be
examined, before we can form a judgment.
artial alkaline tincture certainly contains an iron
divided, in a faline and perfectly diffolved ftate,
is not united to any acid; and as it alfo poffeffes
ous alkaline character, it may be very ufeful in
where martial and anti-acid remedies are at the
indicated; and thefe cafes are very frequent, as
hyficians well know.
fine faffron of Mars may be feparated from this
either by precipitating the iron by gradually fatu-
alkali with any acid, or by a fpontaneous depo-
ferruginous fediment, which is flowly formed in
he fame manner as in the acid folutions of iron.
only obferve, that the iron which has been thus
by an alkali is very foluble in acids; fo that
to be precipitated by an acid, we muft take care
d a drop more than is neceffary for the perfect fa-
f the alkali, otherwife all the precipitate inftant-
ears, and the liquor becomes clear and almoft
*See* ALKALI *and* IRON.

TURE *of* MARS (TARTARISED).

aration, like the preceding, is called a tincture,
it contains nothing fpirituous, but merely from
color. It is a folution of iron by the acid of
nd is a true *martial foluble tartar*, as we fhall

ombination is made, according to the Paris dif-
in the following manner. Six ounces of clean
iron and a pound of powdered white tartar are
ed together in an iron veffel; the mixture is to
ned with a fufficient quantity of water to form it
afs, which muft be left undifturbed during 24
t the acid of tartar may begin to act upon the

iron. Then ſix Paris pints [12 pounds] of pure wat
are poured on the mixture, and boiled together during tw
hours. From time to time the mixture muſt be ſtirre
during the boiling, and hot water is added to ſupply th
place of that which is evaporated. The liquor is then
be left to ſettle, and to be filtrated and evaporated to th
conſiſtence of a liquid ſyrup. Laſtly, an ounce of ſpir
of wine is to be added to it, to prevent the ſolution fro
becoming mouldy.

In this operation, the acid of tartar diſſolves the iro
becomes ſaturated, and forms with it a neutral ſalt, whi
is not only very ſoluble in water, but which is even ve
deliqueſcent: hence this ſalt cannot be cryſtallized, but
obtained in the ſtate of a liquor, or of an extract, ſom
times dry and ſometimes ſoft, according as it has be
more or leſs evaporated. The color of this ſalt is red,
brown, and its taſte is the ſame as that of all ſalts
baſes of which are iron, though ſomewhat leſs auſtere a
ſtyptic.

The union of the acid of tartar with iron is very w
and ſuperficial in this combination; and hence this ſal
very deliqueſcent. This deliqueſcence is ſurprizing, c
ſidering that, as we have remarked elſewhere, the two ſ
ſtances which compoſe it have little or no ſolubility
water. From this difficult ſolubility in water of the co
ponent parts of this tartariſed tincture we may conclu
that in whatever proportions theſe parts are mixed togeth
this tincture muſt always be a neutral ſalt, perfectly
nearly ſaturated: for if any portion of tartar be not co
bined with iron, it will remain at the bottom of the veſ
or upon the filter; and the ſame obſervation may be ap
ed to the iron that is not combined with the tartar.
verthelefs, as pure tartar is ſoluble in water, and as c
ſequently a ſmall portion of it may remain unſaturate
the liquor, it would be proper, if this martial ſol
tartar be required perfectly neutral, to add more filing
iron than are ſufficient to ſaturate all the acid; bec
the ſuperabundant quantity could not remain in the ſ
tion, and becauſe by this method of employing a l
quantity of filings, the operation may be much ſhorter
whereas it would be very long, if more filings were
ployed than is required for the ſaturation of the ta
and if at the ſame time all the tartar was required t
ſaturated.

artarised tincture of Mars has the same medicinal as the other saline and soluble preparations of iron; , as we have said, the least styptic. Accordingly, where martial preparations are indicated, and at the e the styptic quality of iron is apprehended, this the best preparations of iron that can be prescribed. not essentially differ from the infusion of martial *ee* IRON, *and* TARTAR.

CTURE *of* METALS, *or* LILLY *of* PA-LSUS. This preparation may be made by several ; but as they do not much differ, we shall here easiest and readiest.

parts of martial regulus of antimony, one part of and one part of pure copper, are melted together ible. The allay thus compounded is to be pow-hen cold, and mixed with thrice its weight of nitre. The mixture is to be thrown at different to a red-hot crucible, where it detonates, and is o a violent fire, till the metals be perfectly reduced . The matter is to be taken from the crucible d-hot, and immediately thrown into a heated iron where it is quickly powdered. The powder is to while yet hot, into a matrass, and upon it some spirit of wine is to be poured to a height equal to dth of four fingers. The digestion is continued ome days, or till the spirit of wine has acquired a yellowish-red color. The spirit is to be decanted in a bottle; and is called the *Tincture of Metals, f Paracelsus.*

this name *Tincture of Metals*, we find that the spirit was supposed to extract something from the metals h it was digested in this process; perhaps its e rise to this opinion. Nevertheless, as Mr. Baron erves in his Notes on Lemery, if we consider that llic matters are reduced almost to the state of pure y calcination, we shall be convinced that no part can be dissolved by the spirit of wine. Besides, umé, having particularly examined this prepara-as convinced by experiments that no metallic an be separated from it. But although it con-metallic matter, we do not say that it is in-or that it has no other qualities but those of spirit of wine. On the contrary, we know that is alkalised in this operation; and that this alkali, capable of being rendered as caustic by metallic

calxes, as it is by quicklime, acquires a power of acting ſingularly and effectually on ſpirit of wine, which it partly decompoſes. This alkali either forms with the ſpirit of wine, or it ſeparates from this ſpirit, an oil, with which it combines, and to which it gives color, and a very acid taſte. Hence the tincture of metals reſembles much the *tincture of ſalt of tartar*, of which we ſhall afterwards treat and like which it has a ſpirituous, ſaponaceous, acrid, and alkaline character. Accordingly, it is ſucceſsfully uſed when the fibres and veſſels require to be excited and animated; as in apoplexies, palſies, dropſies. For the ſame reaſon, it is capable of accelerating the motion of the blood and of encreaſing certain ſecretions and excretions, particularly ſweat and urine. The doſe of this tincture is from ſix or twelve drops to forty or even more, and it muſt be adminiſtered in ſome proper cordial.

TINCTURE *of* GOLD. *See* GOLD (POTABLE).

TINCTURE *of* SALT *of* TARTAR. This tincture is made by pouring ſome rectified ſpirit of wine to a height equal to the breadth of three or four fingers, into a heated matraſs that contains ſome hot ſalt of tartar, which had been previouſly fuſed in a crucible and powdered. The matraſs is to be cloſed, and the digeſtion is to be continued during ſeveral days with a gentle heat, or till the ſpirit of wine has acquired a fine reddiſh-yellow color.

This preparation is eſſentially the ſame as the tincture of metals, as in both theſe, the fixed alkali acts upon and colors the ſpirit of wine; with this difference only, that as the alkali of tartar, in its ordinary ſtate, is much less cauſtic than when it has been calcined with metallic calxes, it therefore acts leſs quickly and powerfully in the tincture of ſalt of tartar than in the tincture of metals. Accordingly the former preparation is more deeply colored than the latter. But if in the preparation of the tincture of ſalt of tartar, an alkali previouſly rendered cauſtic by quicklime be employed, the tincture will be as red and active as the tincture of metals; and hence the medicinal qualities of theſe two tinctures are the ſame.

TINCTURES *of* VEGETABLE *and* ANIMAL SUBSTANCES. Many medicinal preparations are called tinctures, becauſe they are made by digeſting certain vegetable and animal ſubſtances in ſpirit of wine, to which they communicate different colors, according to their nature.

Som

of these tinctures are made with one vegetable or ubstance only. These are called *simple tinctures*, are distinguished by the name of the vegetable or natter employed; such are the tinctures of myrrh, of saffron, of castor, and many others.

s contain a greater or less number of different e and animal substances, which are digested in wine, according to the several receipts. These general name of *compound tinctures*, and are also shed by the names of their particular authors and

hall not here enter into a detail of these several tinc- ecause they are rather objects of pharmacy than of y; but shall confine ourselves to the following gene- vations.

as vegetables and animals are composed of several es which are not all soluble, or not equally soluble of wine, we cannot consider spirituous tinctures as e extracts of the vegetable and animal substances em- n their preparation.

dly, the principles of these substances upon which wine can act, are volatile essential oils, and others me nature; resins, properly so called; any oils that saponaceous state, and soluble in water by means saline matter; acids; and lastly, several kinds of salts. And the principles which spirit of wine dissolve directly, are sweet oils and oily concretions not volatile nor saline; substances purely gelatinous mmy; earthy matters not saline nor soluble in and lastly, many neutral salts, which are insoluble of wine, the various kinds of which have not yet termined.

dly, many of the vegetable and animal principles e essentially unsoluble in spirit of wine, particularly jellies, and neutral salts, are soluble in water.

thly, from the last observation we may perceive, that s drawn from the same vegetable or animal substance ffer considerably, according to the state of dryness substances, and the dephlegmation of the spirit of nployed. For a tincture made from moist plants, h a weak spirit of wine, must contain some gummy ne principles, which could not be contained in a made with the plants perfectly dried, and a spirit perfectly rectified.

Fifthly, as many chemical experiments ſhew that ſu ſtances naturally unſoluble in any certain menſtruum, m be rendered ſoluble in that menſtruum by ſome other int mediate ſubſtance; and as, amongſt the vegetable a animal principles, ſome ſuch intermediate ſubſtances m exiſt; we cannot therefore affirm that ſpirituous tinctu contain no other of theſe principles but ſuch as are n turally ſoluble in ſpirit of wine; but we rather think t they probably do contain other principles. This ſubj has not been examined ſufficiently to enable us to ſp upon it in a leſs vague and general manner than we n do. *See* ANALYSIS *by* MENSTRUUMS, *and* SPIRIT (A DENT).

TIN-GLASS. This name is frequently given to ſemi-metal biſmuth. *See* BISMUTH.

TOBACCO. *(r)*

TOPAZ. *(s)*

TORREFACTION. This name is given to a k of calcination by which ores are deprived of the vola mineraliſing ſubſtances, the ſulphur and arſenic wh they contain. It is alſo applied to ſignify the roaſting of ſo pharmaceutical preparations. Thus, for inſtance, we *torrefied rhubarb*, &c.

TRAGACANTH (GUM). *See* GUM.

*(r)* TOBACCO. The leaves of this plant being diſtilled i retort, without addition, yield an acrid, empyreumatic, poiſ ous oil. Tobacco loſes its virulence by long coction in wat From an ounce of American tobacco, water extracted four dra and thirty grains; and from an ounce of the ſame tobacco, ſp of wine extracted one dram and thirty grains. The ſpiritu extract was ſtronger than the aqueous. The former had a f green color; the latter was yellowiſh-brown. The diſtil water and ſpirit of tobacco have no taſte or ſmell. *Neuman.*

*(s)* TOPAZ is a precious ſtone, of a golden color, the fourth hardneſs from diamonds. Mr. Pott has made ſome curious exp riments on the Saxon topaz. He found that this ſtone could n be fuſed with even eight times its weight of fixed alkali, but th it was vitrifiable by addition of half its weight of borax, or thr its weight of chalk. It was alſo fuſed by calxes of lead or of co per, and fuſible ſpar, but not by nitre.

This ſtone may be imitated by fuſing a mixture of two ounc of powdered rock cryſtal with ſeven ounces of red lead.

POLI. *(t)*

TORIUM. *(u)*

TURATION is an operation which consists in chanical division of bodies, and is executed by the ethods, and by the same instruments, that are d for other divisions of this kind; that is to say, ars, upon porphyries, and in mills. *See* DIVISION. ord is generally applied to denote the division that of several bodies together, to unite them with each as, for instance, the extinction of mercury in the n of Ethiops mineral, and others similar.

RBITH MINERAL. This name is given to a tion of mercury made in the following manner. mercury is put into a glass-retort, and upon it is an equal weight of concentrated vitriolic acid, or ccording to the degree of concentration of this acid. matters are to be distilled together in a sand-bath till remains in the retort but a dry saline substance,

RIPOLI is an earth consisting of very fine particles. It for polishing hard bodies. Tripoli is not fusible in the colors are various; grey, yellow, white. It becomes rd and compact in the fire, as clay does; and from this probably it has been considered as an argillaceous earth; t does not appear to have been sufficiently examined. It imagined to be a powder formed by the decomposition dering of jasper. Neuman says, that by distilling two f it, he obtained two scruples of a weak marine acid, and portion of sal ammoniac; that by distilling a mixture of h and nitre he obtained aqua-regia; and that of sixty f Tripoli, one grain was soluble in concentrated vitriolic o in diluted vitriolic acid, three in spirit of salt, five in nitre, eleven in aqua regia, and seven grains in caustic ali.

TRITORIUM. A vessel generally made of glass, used for ation of liquors of different densities, as oil and water. st diameter is the middle, and it terminates with an aper- ach of the two extremities. The lower extremity, the of which is very narrow, is dipped into the mixed liquor, n it is sufficiently filled, the upper orifice is to be stopped pressing the thumb upon it, by which means the liquor d will not run out at the lower aperture when the vessel is rom the mixed liquor. When the fluids, of which this onsists, have perfectly separated according to their respec- sities, by removing the thumb the heavier fluid will run the lower extremity, and the separation will be thus

which is a combination of mercury with vitriolic acid. Th union of these two matters cannot be directly effected bu by this process, because the vitriolic acid cannot attac mercury unless it be highly concentrated, and because thi concentration cannot be performed so well in open as i close vessels. *See* CONCENTRATION. Besides, the hea in this operation favours considerably the action of the aci upon the mercury. The acid which passes into the receive during the distillation, is very suffocating and sulphureous which qualities it receives from the phlogiston of the mer cury.

The white saline mass left at the bottom of the reto is to be put into a large vessel, and upon it large quantitie of hot-water are to be poured at several different times This water weakens the acid, takes it from the mercury which is then precipitated towards the bottom of the vess in form of a very shining yellow citron-colored powde This yellow mercurial powder, having been well washe is called *turbith-mineral*, and is a very powerful emetic.

The tartar with which it is washed contains the acid th was united with the mercury; but it also contains a littl mercury, that remains in a saline state, and is soluble i water, by means of the very large quantity of acid.

Most chemists, especially Mr. Rouelle, have believe that a portion of vitriolic acid remains united with the tu bith mineral, but too little to render it soluble in wate On the contrary, Mr. Beaumé, having examined th matter, affirms that turbith mineral contains no acid, whe it has been sufficiently washed; and by frequently boilin this preparation in a large quantity of distilled water, n a vestige of acid will adhere to it. *

Turbith mineral may also be made, by precipitatin mercury from its solution in nitrous acid by means vitriolic acid, or of some vitriolic salt. For this purpo the nitrous acid must be well saturated with mercury for if it contains any unsaturated acid, no turbith mi neral will appear upon adding either vitriolic salts pure vitriolic acid. Hence mistakes may be committe in making experiments to discover the presence of vitriol acid by means of a solution of mercury, as is frequent done.

* The latter experiments of M. *Bayen* prove, that turbith m neral does contain vitriolic acid.

W

ught also to observe, that turbith mineral becomes only by being deprived of the adhering vitriolic d that it remains white till it has been washed with a uantity of water; in general, the more perfectly it ed of acid, the deeper yellow color it acquires.

ith mineral has been formerly celebrated for the he venereal disease; but it is now little used, because le mercurial remedies have been discovered. *See* VITRIOLIC), *and* MERCURY.

RPENTINE. *(x)*

TENAG. *(y)*

'URPENTINE is a resinous juice extracted from several Sixteen ounces of Venice turpentine being distilled with ielded four ounces and three drams of essential oil; and quantity distilled without water, yielded with the heat er-bath, two ounces only. When turpentine is distilled l with water till it becomes solid, it appears yellowish; e process is further continued, it acquires a reddish-brown In the first state it is called boiled turpentine, and in the colophony or common rosin. On distilling sixteen ounces rt with an open fire encreased by degrees, we obtain, first, ces of a limpid colorless oil; then two ounces and two f a thicker yellow oil; and lastly, two ounces and a dram k-brownish red empyreumatic oil, of the consistence of a and commonly distinguished by that name.

*ssential oil* commonly called *spirit of turpentine*, cannot singular difficulty be dissolved in spirit of wine, though ne itself is easily soluble in that spirit. One part of the be dissolved in seven parts of rectified spirit of wine; but ing a while, the greatest part of the oil separates and falls ottom. *Neuman.*

'UTENAG. This name is given in India to the semi-metal is also sometimes applied to denote a white metallic comrought from China, called also *Chinese copper*, the art of which is not known in Europe. It is the best imitation of hich has been made. It is very tough, strong, malleable, easily cast, hammered and polished; and the better kinds when well manufactured, are very white, and not more to tarnish than silver is. Three ingredients of this comay be discovered by analysis, namely, copper, zinc and

VALERIAN. *(a)*

VENUS is the name of a planet, which chemi have alſo applied to ſignify copper.

VERDIGRISE. Verdigriſe is copper corroded a reduced to a very beautiful green ruſt, by a vi ous ac This matter, which is uſeful to painters, is conveniem manufactured at Montpellier; the wines of Languedoc, which that city is the capital, being very proper for this p paration.

The following proceſs for making verdigriſe is deſcrib by Mr. Monet of the Royal Society of Montpellier, and publiſhed among the Memoirs of the Academy for the ye 1750 and 1753.

Vine-ſtalks well dried in the ſun are ſteeped during eig days in ſtrong wine, and afterwards drained. They then put into earthen pots, and upon them wine is pour The pots are carefully covered. The wine undergoes acetous fermentation, which in ſummer is finiſhed in ſeven eight days, but requires a longer time in winter, althou this operation is always performed in cellars. When fermentation is ſufficiently advanced, which may be kno by obſerving the inner ſurface of the lids of the po which during the progreſs of the fermentation is co tinually wetted by the moiſture of the riſing vapors, ſtalks are then to be taken out of the pots. Theſe ſta are by this method impregnated with the acid of the wi and the remaining liquor is but a very weak vinegar. T ſtalks are to be drained during ſome time in baſkets, a layers of them are to be put into earthen pots with pla of Swediſh copper, ſo diſpoſed that each plate ſhall reſt up and be covered with layers of ſtalks. The pots are to covered with lids, and the copper is thus expoſed to action of the vinegar, during three or four days or mo in which time the plates become covered with verdigr The plates are then to be taken out of the pots, and in the cellar three or four days; at the end of which ti

*(a)* VALERIAN. An ounce of the dry root of valerian yiel with rectified ſpirit of wine three drams and ſix grains of refin extract, and the ſame quantity with water yielded four drams twenty-one grains. The diſtilled ſpirit is ſlightly, and diſtilled water is ſtrongly, impregnated with the ſmell of the va rian, but no ſeparable oil is obtained. The moſt active prepa tion is the ſpirituous extract, which contains all the uſeful ma of the root. *Neuman.*

t

to be moiſtened with water, or with the weak
bove-mentioned, and left to dry. When this
g and drying of the plates has been thrice re-
ne verdigriſe will be found to have conſiderably
in quantity, and it may then be ſcraped off for

ion or eroſion of copper, and conſequently a ver-
nay be prepared by employing ordinary vinegar
wine, as is directed in the above proceſs. But it
t have the unctuoſity of ordinary verdigriſe, which
neceſſary in painting. Good verdigriſe muſt
ed by means of a vinous acid, or ſolvent, half
l half ſpirituous. Accordingly, the ſucceſs of
ion depends chiefly on the degree of fermentation
the wine employed has been carried: for this
ion muſt not have been ſo far advanced that
ly vinous or ſpirituous part remained in the

riſe is uſed for painting, as it furniſhes a fine green
en mixed with oil. It enters alſo as an ingre-
o ſeveral plaiſters and ointments. In Chemiſtry,
is uſed for the extraction of radical vinegar;
he preparation of *cryſtals of verdigriſe*, or *of Venus*.
STALS *of* VENUS, COPPER, *and*. VINEGAR.

DITER. *(b)*

ELS (CHEMICAL) *and* UTENSILS.

ſhewn at the article LABORATORY, how a che-
oratory ought to be diſpoſed, and the principal

RDITER is a blue pigment obtained by adding chalk
ng to the ſolution of copper in aqua-fortis. It is pre-
refiners of ſilver, who employ for this purpoſe the ſolu-
pper, which they obtain, in the proceſs of parting, by
ng ſilver from aqua-fortis with plates of copper. *See*
. It is ſaid that a fine colored verditer cannot be obtain-
ſolution of copper prepared by diſſolving directly that
qua-fortis; and that the ſilver is neceſſary. We know
ctually made by the refiners only. Dr. Merret ſays that
red in the following manner: A quantity of whitening
a tub, and upon this the ſolution of the copper is
This mixture is to be ſtirred every day for ſome hours
ill the liquor loſes its color. The liquor is then to be
, and more ſolution of copper is to be added. This is
ated till the whitening has acquired the proper color.
to be ſpread on large pieces of chalk, and dried in

utenſils

utensils with which it ought to be furnished. At the arti FURNACES, we have mentioned whatever is essential to known concerning those instruments. Lastly, we h described under each particular name, the principal ves employed in chemical operations. Nothing therefore mains but to make here a kind of enumeration, useful those who would furnish a laboratory; which enumerat may be considered as a compleat supplement to that wh is given at the article LABORATORY.

The ancient chemists, and especially the alchemi have invented vessels of many various kinds and whimsi shapes, suited to their several operations. But now number and variety of those vessels are much diminish either because modern chemists have not so much tience for such tedious and perplexed operations as alchemists had; or because they have found that th operations can be performed with vessels of a simpler fo and less various. Accordingly the vessels required i laboratory are few and simple, which is certainly an adv tage. The chief of these vessels are,

*Copper Alembics*, with their *refrigeratories*, *worms*, and *ceivers*. *See all these words*, *and* PLATE I.

*Alembics of Glass*, of *Stone*, and *Earthen-Ware*, of di rent sizes, with their *receivers*, which are matrasses w longer or shorter necks. *See* PLATE I.

*Adopters*, which are small receivers with two necks, use of which is to encrease the distance of the receiver f the distilling vessel and the furnace.

*Aludels of Earthen-Ware*. *See* PLATE I.

*A Balance*. *See this word*.

*Balloons*, which are matrasses with large bellies short necks. They are used as receivers. *See* B LOONS.

*Bottles* of all kinds and sizes. A great number of the required in laboratories, to contain the different liqu and substances that are volatile, deliquescent, or corro The most necessary of these are large glass bottles c taining three, four, six pints, or more, of any form, containing those matters that are used in large quanti *Crystal-glass Bottles* with glass stopples, to contain all v tile or corrosive liquors. The small bottles or *Phials* very convenient, and may be used as matrasses in m operations. *See* MATRASS.

*Glass Jars* are cylindrical vessels useful for contai many dry and not volatile substances. Their mouth

gene

closed with cork or with paper. Large jars are
t for the mixing of liquors, for precipitations,
great number of these is required of different

of metal. These are useful for evaporations.
generally of copper; but as this metal is very
e corroded by saline matters, a silver bason is very
t.

, or *Dishes* of glass, of stone-ware, and of crystal-
ich are the best of any. These are used in the
ns of corrosive matter capable of acting upon
Some also are made of crucible-earth, and of
, which are employed for containing the sand
aths.

*one.* This is a cast-iron vessel of the form of a
ne, to the point of which is fixed a pedestal, that
nd firmly, with its point turned downwards. The
s cone is to receive metallic matters melted with
stances, all which being poured into it, the me-
s of the mixture sink by their weight to the point
verted cone, and are there collected in form of a
The cone ought to be heated, and greased with
efore the melted matters are poured into it.

. *See that word.*

*es* are kinds of earthen pots of a cylindrical,
or triangular figure, used for fusions of all kinds.
ght to be covered with lids. *See* POTTERY.

*Funnels.* These ought to be of various sizes;
ary for small filtrations, and for the pouring of
nto bottles.

*oulds* are iron vessels of a certain thickness, of the
hollow semi-cylinders, to which a handle is an-
The surface of their semi-cylindrical cavities
be very smooth. They are of various sizes. The
ese vessels is to receive melted metals into their
the form of which is given to the metals, which
called *ingots.* We ought always to heat and to
ese moulds before the melted metal is poured into
*See* PLATE I. *Fig.* 11.

*rs. See that word.*

*sses* are long-necked bottles. Some of these have
nd some flat bottoms. Some are shaped like an egg,
nce are called *philosophic eggs.* Matrasses are used
*ons and digestions.*

*Muffles.*

*Muffles.* These vessels, which ought to be made o crucible earth, have the form of a hollow cylinder divide in the direction of its axis, and closed on all sides, except ing its front. This vessel represents an oblong arch o vault, the hinder part of which is closed by a semi-circula plane, and the lower part or floor of which is a rectangula plane. It is a little oven that is placed horizontally i essay and enamelling furnaces, so that its open side cor responds with the door of the fire-place of the furnace Under this arched oven small cupels or crucibles are placed and the substances contained are thus exposed to heat withou contact of fuel, smoke, or ashes. *See* FURNACE (ESSAY) PLATE I. *Fig.* 9, and PLATE II. *Fig.* 1.

*Pelicans. See that word, and* PLATE I. *Fig.* 6.

*Receivers. See that word, and* PLATE I. *and* II.

*Circulatory Vessels.* Two matrasses are so called, int the largest of which the matter to be operated upon is t be introduced; and the neck of the smaller matrass is t be fitted into the neck of the former, so as to be a kind o stopple to it. The joining is to be closed with a lut suitable to the vapors intended to circulate. By mean of this apparatus, one or more substances may be digeste during a long time without any evaporation, because th vapors which arise are condensed in the small matrass tha serves as a stopple, and continually fall back upon th matter in the great matrass. It is, as we see, a very simpl apparatus, which produces the same effect as the pelican.

*Subliming Vessels.* This name was formerly given to long-necked matrass, which being covered with a capital formed a kind of alembic. It was employed in the distil lation and rectification of very volatile substances; but sinc we have found that the length of the neck of an alembi is quite useless, these have been quite abandoned. Accord ingly, the true subliming vessels are those that are actuall employed in sublimations. *See* ALEMBICS, ALUDELS, MA TRASS, *and* SUBLIMATION.

VINEGAR. Vinegar is a vegetable spirituous acid produced by the second degree of fermentation, or by tha fermentation which succeeds the spirituous, and is calle the *acid* or *acetous fermentation.*

From this definition it appears, that wine only, or vinou liquors can be changed into true vinegar. Every liquo which has completely undergone the spirituous fermenta tion, is spontaneously and necessarily disposed to the ac fermentation. Accordingly every wine does continuall ten

come vinegar, and actually is changed into vine-
r or later, according to circumſtances; unleſs
ge be prevented by ſome obſtacle to fermentation.
. Vinegar may therefore be made not only from
apes, but alſo from cyder, beer, and, in a word,
her wines. But as the wine of grapes is preferable
rpoſe, we ſhall deſcribe the method of converting
egar.

egar is produced by a fermentation, its qualities
ich on the method of exciting and of conducting
ntation. The wine which is generally converted
ar, and which for its cheapneſs is generally em-
r this purpoſe, is ſuch as has already become
hough the better and the more ſpirituous the
nd alſo the more of the vinous ſpirit that can be
n the vinegar, the better and ſtronger this will be.
ays, in his *Phyſica Subterranea*, that having di-
ne in order to convert it into vinegar in a bottle
lly ſealed, he found, that although a longer than
ary time was required, the vinegar produced was
nger then when free air is admitted. Mr. Car-
lſo affirms, that the ſtrength of vinegar may be
reaſed by adding ſome aqua vitæ to the wine be-
expoſed to the acetous fermentation.

nt methods are practiſed by manufacturers for
inegar, who are generally believed to be poſſeſſed
ſecret for that purpoſe. Nevertheleſs no more
uiſite in the preparation of good vinegar, than to
ood wine, and to conduct the fermentation in the
antageous method; in the ſame manner as good
only be made from good muſt, and by a well con-
rmentation. The principal part of theſe opera-
erformed by nature.

nethod of making vinegar conſiſts in mixing the
be fermented with its dregs, and its tartar, and in
this liquor to a heat of about eighteen or twenty
This fermentation ſeems to require more heat
ſpirituous. It alſo excites more heat and tumult;
ugh it ought to be allowed to proceed briſkly, yet
ſſary from time to time to check it.

ave deſcribes, in his Elements of Chemiſtry, the
; proceſs, which ſeems to be well contrived, for
ng of vinegar.

two large oaken vats or hogſheads, and in each of
ce a wooden grate or hurdle, at the diſtance of a
foot

foot from the bottom. Set the veſſel upright, and on grate place a moderately cloſe layer of green twigs, or fr cuttings of the vine. Then fill up the veſſel with the fo ſtalks of grapes, commonly called the *rape*, to the top of veſſel, which muſt be left quite open.

Having thus prepared the two veſſels, pour into them wine to be converted into vinegar, ſo as fill one of th quite up, and the other but half full. Leave them thus twenty-four hours, and then fill up the half-filled ve with liquor from that which is quite full, and which now in its turn be left only half-full. Four-and-twe hours afterwards repeat the ſame operation, and thus go keeping the veſſels alternately full and half-full dur every twenty-four hours till the vinegar be made. On ſecond or third day there will ariſe, in the half-filled ve a fermentative motion, accompanied with a ſenſible h which will gradually increaſe from day to day. On contrary, the fermenting motion is almoſt imperceptibl the full veſſel; and as the two veſſels are alternately and half-full, the fermentation is by that means, in ſ meaſure, interrupted, and is only renewed every other in each veſſel.

When this motion appears to have entirely ceaſed, e in the half-filled veſſel, it is a ſign that the fermentatio finiſhed; and therefore the vinegar is then to be put i caſks cloſe ſtopped, and kept in a cool place.

A greater or leſs degree of warmth accelerate or che this, as well as the ſpirituous fermentation. In Franc is finiſhed in about fifteen days, during the ſummer; b the heat of the air be very great, and exceed the twe fifth degree of Mr. Reaumur's Thermometer, the h filled veſſel muſt be filled up every twelve hours; bec if the fermentation be not ſo checked in that time, it become violent, and the liquor will be ſo heated, many of the ſpirituous parts, on which the ſtrength the vinegar depends, will be diſſipated; ſo that noth will remain, after the fermentation, but a vapid liq ſour indeed, but effete. The better to prevent the diſſ tion of the ſpirituous parts, it is a proper and u precaution to cloſe the mouth of the half-filled veſſel which the liquor ferments, with a cover made of oak-w As to the full veſſel, it is always left open, that the may act freely on the liquor it contains: for it is not li to the ſame inconveniences, becauſe it ferments but ſlowly.

*Dictionnaire Portatif des Arts et Metiers*, another
described, by which a very good vinegar is com-
de at Paris from the lees of wine. For this
l the wine contained in the lees is pressed out,
nto large casks, the bung-holes of which are left
hese casks are put into a hot place; and if the
on proceeds too fast, it must be checked by
re fresh wine. This process is very similar to the

pearances which accompany the acetous fermen-
mble much those that occur in the spirituous
on. In both fermentations, an intestine motion,
a hissing noise, and an ebullition, may be per-
There are nevertheless essential differences between
sides that the products of the vinous and acetous
ons differ exceedingly, the heat produced by
is scarcely sensible, while that produced by the
nsiderable. Secondly, we have reason to believe,
apor which exhales from vinegar during fermen-
not noxious, as the vapor of fermenting wine is;
has not been observed to produce such bad effects.
ontrary, as the acid of vinegar more and more
or unfolds itself, it seems to acquire more power
nd retain the inflammable principle, which is
angerous part of these vapors. Lastly, vinegar
deposit tartar as wine does, even although it has
e with wine that had not deposited its tartar.
ediment of vinegar is a viscid, oily, and very
matter. The grape-stalks used in the making of
to promote and increase the fermentation, are
er with this matter during the operation. They
ally washed clean, and carefully preserved, to
he fermentation of more vinegar; because the acid
h they are soaked acts powerfully as a leaven or
The casks also which have been used for the
n of vinegar are to be cleansed from the above-
viscid matter, and kept for the same use, as they
ed fitter than new casks for the preparation of

he acetous fermentation is finished, the nature and
ter of the liquor that has undergone it are totally
Wine has a taste and smell, partly spirituous,
acid; but in good wine the spirit so much
ver the acid, that the latter is scarcely perceptible.
and smell of vinegar also is partly acid and partly

 spirituous;

ſpirituous; but the former quality ſo entirely prevails, t
the latter is almoſt totally concealed.

We cannot form any very clear and diſtinct knowle
of the manner in which Nature performs theſe char
in fermenting liquors. The properties of wine and vi
gar prove, that the acetous fermentation unfolds in a v
ſingular manner the acid parts of wine, and intima
combines them with the inflammable ſpirit. Hence,
changing wine into vinegar, its ardent ſpirit is ſo cov
by the large quantity of acid, that it is no longer
ceptible; that it now cannot affect the head and intoxic
and that if it be diſtilled, the firſt liquor that riſes v
a heat leſs than that of boiling water is not an ardent ſp
as when wine is diſtilled, unleſs the vinegar be too n
and the acetous fermentation has not been comple
finiſhed; in which caſe the vinegar yields a little ar
ſpirit: but when old vinegar is diſtilled, the liquor
riſes firſt is a ſlightly acid phlegm, which contains the r
volatile, the moſt odoriferous, and the moſt ſpirituous
of the vinegar.

The acid of vinegar is employed in many chemical
pharmaceutical preparations, for which not common v
gar, but the acid ſpirituous part of vinegar that is obta
by diſtillation, called *diſtilled vinegar*, is chiefly employ

The proceſs of diſtilling vinegar is very ſimple.
quantity of good ordinary vinegar is put into a large cu
bit or ſtill, which ought to be made of ſtone-ware, and
of metal, as the acid of vinegar is capable of acting u
moſt metals. This cucurbit is ſunk in a deep furn
ſo that five or ſix fingers breadth only near its neck
pears. The neck is to be carefully luted with clay
round the furnace, that the capital may not be he
too much. A capital and a glaſs receiver are then t
fitted, and the diſtillation is to be begun with a very ge
heat. The acid ſpirituous liquor paſſes by drops into
receiver. This liquor is white, tranſparent, penetrat
ſomewhat empyreumatic, and diſengaged from an
but not ſpirituous ſubſtance, and alſo from an extra
ſaponaceous matter, both which are contained in ordi
vinegar. Theſe latter ſubſtances remain in the ſtill
the coloring matter, and form together an extremely
extract of vinegar. This reſiduum contains alſo ſome
tar, and by incineration yields much fixed alkali, as
matters belonging to vines, grapes, or wine, do.

ıld be much mistaken if we believed that the
ous portion of the vinegar that rises in this distil-
stronger acid than the vinegar itself. Vinegar
illed with an intention to concentrate it, but
engage it, as we have said, from its extractive
acid which this part contains is not, properly
inegar, but is oily, not spirituous, less volatile
ormer, or even than water. Accordingly, the
ed in this distillation, when well conducted, is
ıous and also more watery than the acid of the

have attempted different methods of concen-
illed vinegar. Stahl has taught us the best
depriving it of its water without any alteration.
od consists in exposing it to a cold sufficiently
freeze its watery part, which is afterwards sepa-
mps of ice, from the more acid part. Thus
vinegar may be considerably concentrated. *See*
TRATION *of* VINEGAR *by* FROST.
of vinegar may be more effectually concentrated
ng it with alkalis, earths, and metals, as any
nay. Thus, by drying perfectly neutral acetous
xed bases, and afterwards by decomposing them,
e mere action of the fire, or by means of con-
triolic acid, we obtain the strongest acetous acid
produced. This acid is called *radical vinegar*.
*of* VENUS.
of vinegar dissolves all substances upon which
can act, and forms with them neutral salts,
ich have particular names, but which all might
*etous salts*.
careous earth this acid forms salts that in crystal-
into silky ramifications and vegetations. These
med from their earthy bases, *salt of chalk*, *salt of*
&c.
ed vegetable alkali it forms a very pungent and
escent salt, called *regenerated tartar*, or *terra*
*ri*. *See* TERRA FOLIATA.
ed mineral alkali it forms a neutral crystallizable

latile alkali it forms *an acetous ammoniacal salt*,
*of Mindererus*.
combinations of the acetous acid with metallic
ave not been yet examined. The combinations
l with lead and with copper are best known,

 because

because they furnish several preparations used in pa
ing, and some other arts. This acid united with co
forms *verdigrise* and *crystals of Venus*; and with lead f
*cerus*, and *salt or sugar of lead*. *See these several art*
The vinegar in which lead is dissolved is called *vineg*
*lead*, and is sometimes used as a cosmetic, for repe
cutaneous eruptions. But this cosmetic ought not t
employed but under the direction of a prudent physician
it may occasion a dangerous translation of the morbid
mour to other parts.

Mercury dissolved first by nitrous acid, and afterw
precipitated by fixed alkali, is quickly soluble in vin
with which it forms a mercurial acetous salt. The cry
of this salt are shining silver-like plates, not very solub
water. *See* MERCURY.

Vinegar very much concentrated, as the rectified
of Venus, or radical vinegar, being distilled with equal
of highly rectified spirit of wine, furnishes a liquor w
has all the essential characters of ether, or rather is a
ether, called *acetous ether*. The discovery of this ether
lately made by the Count de Lauraguais. *See* E
(ACETOUS)

Vinegar being an oily, spirituous, vegetable acid is m
weaker than mineral acids, which are less compoun
Accordingly all acetous neutral salts may be decomp
by any mineral acids, excepting the vitriolic acid w
very much sulphurated, which cannot be considered
pure acid.

According to Mr. Gellert's Table, the affinities o
acetous acid are in the following order: Inflammable
ciple, zinc, iron, copper, lead, and bismuth. C
silver, tin, and mercury, are marked in this Table as i
pable of uniting with this acid.

Vinegar is very useful, not only in ordinary life a
agreeable seasoning for many kinds of food, but als
medicine, in chemistry, and in several arts.

This acid is in general antiseptic, and is considere
incisive and aperitive. It is used as a vehicle in m
preparations which possess these qualities. Thus
*oxymel* is a syrup made of honey and vinegar. Such als
*oxymel of squills*, and several other compound vinegars
the use not only of medicine, but also of the toil
receipts for all which are found in Dispensatories.
very important medicinal virtue has been attributed to v
gar, namely, that of curing the canine madness.

Buc

in a work entitled, *An Historical Treatise of Plants* *Lorraine and the Three Bishopricks*, affirms, that cessful trials have ascertained the efficacy of vine- the ill effects arising from the bite of mad dogs, s given in the quantity of a pound each day, to three doses; one to be taken in the morning, noon, and the third in the evening. The dis- this quality of vinegar was made accidentally at Trioul, a province belonging to Venice, by an of that town, who having been seized with dness, was cured by drinking a glass of vinegar , instead of some medicine that had been prepared

e already mentioned the use of vinegar in several reparations, particularly of cerus and of verdi-

GAR (DISTILLED). This is the spiritu- vinegar obtained by distillation. *See the preceding*

GAR (RADICAL). *See* SPIRIT *of* VENUS.
GAR *of* LEAD. Is a solution of lead or in distilled vinegar. *See the articles* LEAD *and*

IFICATION. Vitrification is one of the ous and most important operations in chemistry. uct of this operation is Glass; a matter which, made, is valuable for its great hardness, beauty, t transparency. These principal and essential glass render it very extensively useful in ordinary tural philosophy, in chemistry, and in many arts, y form may be given to glass, and all kinds of utensils may be formed of it, which are capable the most powerful corrosives and solvents. Glass of receiving and preserving the finest polish. Its of transmitting and refracting the rays of light, ecting these rays when one of its surfaces is covered tallic coat, render it very useful for constructing eleescopes, microscopes, and all kinds of optical or collecting, separating, and decomposing the ght; and for exhibiting many wonderful catop- dioptrical appearances and experiments. If to irable properties we add that of imitating the liant precious stones, opake or transparent, we y be convinced that perfect glass is one of the

moſt beautiful and excellent productions of human
duſtry.

The art of making glaſs is dependant on chemiſtr
all its parts. In its principles it is ſimple, but exten
in its detail, and difficult in its practice. The exten
this art does not permit us to enter into the particul
or into its ſeveral branches. In this article we ſhall en
your to explain the chemical principles upon which the
depends, and which may direct experimental philoſoph
as well as intelligent artiſts, in their reſearches to
prove it.

Perfect glaſs, or the moſt beautiful factitious cryſtal
perfectly ſimilar in appearance to the whiteſt and
tranſparent natural and vitrifiable ſtones. The only
ſible difference between theſe natural and artificial
ductions is, that the latter are much leſs hard and
fuſible than natural cryſtal, or any other vitrifiable ſt
In fact, pure glaſs or artificial cryſtal is eſſentially of
ſame nature as vitrifiable ſtones; or we may rather
that it is vitrifiable earth itſelf rendered more fuſible
by certain additions, as we ſhall ſoon ſhew.

The moſt ſimple and elementary of all earths, called
chemiſts *vitrifiable earth*, forms the hardeſt and moſt tran
rent of all natural bodies, when its integrant parts
united together in a due ſtate of aggregation: but the p
of vitrifiable earth cannot form this aggregation, unleſs
have been previouſly ſo much ſeparated from each ot
that they poſſeſs a mobility which enables them to u
together according to their natural tendency: the integ
parts of elementary earth may acquire this mobility by
methods; namely, by the interpoſition of the parts of wa
or of thoſe of fire.

Almoſt all the vitrifiable ſtones that we know, as diamo
rock-cryſtal, and other hard tranſparent ſtones, appea
have been once diſperſed in infinitely ſmall molecules thro
much water, from which they have afterwards been
poſited, and then have united together and formed the
hard tranſparent maſſes which we now ſee. The regular
uniform cryſtallization of theſe precious ſtones is an evi
proof of this truth.

Poſſibly ſome of theſe ſtones may have been formed
fire, and by a true fuſion. Perhaps even this terreſ
globe has been once, as Mr. de Buffon thinks, one ſp
of melted glaſs, or one immenſe diamond, the outer c
of which only has been changed by the elements, w

or parts ſtill remain in their vitrified ſtate *(c)*: ertainly know, that of the two above-mentioned y which pure ſolid maſſes of vitrifiable earth may l, that of the diviſion and elaboration by water practiſed by human art, on account of the many red for the operation.

ſecond method, namely, *fuſion*, the time required is better adapted to the ſhortneſs of our lives, ly might, with a ſufficient degree of heat, melt earth, and all other kinds of earths; ſince theſe, iciently purified, are reduced to the nature of earth; and we might convert theſe earths into cryſtal, or of hard tranſparent ſtones, as perfect tural precious ſtones. In a word, nothing but a ciently intenſe is required to melt any earthy d to convert it into a diamond, as brilliant and as e moſt perfect natural diamonds: but here a great, rto unſurmountable difficulty occurs, namely, to heat ſufficiently intenſe to melt the moſt pure and rifiable earth; for the moſt violent heat that art produced is inſufficient to melt even many of the mpure earths and ſtones, and is therefore much le of melting that earth, which, becauſe it is the d pureſt, is alſo the moſt unfuſible of all natural *See* EARTH.

we conclude, that although we know by what parts of the pureſt earthy principle may be ſo to form bodies ſimilar to the natural precious we cannot poſſibly put theſe means in execution: cannot artificially produce ſolid maſſes of pure ctly ſimilar in all their properties to the natural ſtones, we can however very well imitate theſe natural productions, not in their hardneſs and y, but in their tranſparency and luſtre; that is, noſt obvious and ſtriking qualities, by means of

Buffon conjectures, that the earth, as alſo the other ight have been parts knocked off from the ſun by a ng upon its ſurface; that they received from the im- he comet their progreſſive motion; and alſo, by the f the ſtroke, their motion round their own axes; that was then in a vitrified and fluid ſtate; and that a led from its ſurface by the violent heat, the groſſer hich, being afterwards condenſed, formed water, and ſe remaining ſuſpended formed air.

compoſitions of glaſs or factitious cryſtal. The ſolut of this problem is founded on the following principles.

Firſt, pure and elementary earth, which makes the pr cipal baſis of all vitrifications, and therefore called vi fiable earth, is indeed unfuſible with regard to us: but know, that certain very fuſible ſubſtances are capable uniting intimately with this earth, and of communicat to it ſome of their fuſibility; ſo that by their means may reduce it to a perfect fuſion.

Secondly, the ſubſtances capable of acting upon earthy principle are the inflammable principle or phlogiſt and ſeveral ſaline matters; but we may remark, that theſe ſubſtances do only act as fluxes by uniting intimat with the vitrifiable earth, and while they themſelves m part of the glaſs; and alſo, as the integrant parts of th fluxes are not capable of forming either with each other, with the parts of vitrifiable earth, ſo ſtrong an adheſior that which can be formed between the parts of the p vitrifiable earth; it follows, that all factitious cry muſt be much leſs hard than natural cryſtals, or other h ſtones; ſince theſe contain only pure vitrifiable earth.

Thirdly, in conſequence of the principle that all co pound bodies partake of the properties of their compon parts, factitious cryſtals ought to partake ſo much more the properties of inflammable and ſaline matters, and ou to be removed ſo much more from thoſe of pure vitrifi ſtones, as they contain a larger quantity of thoſe matt Accordingly we find, that the ſmaller quantity of that is contained in glaſs, the greater hardneſs, luſ and reſemblance to natural ſtones it has, provided fuſion has been compleat. Thus glaſs is ſo much m perfect, as it poſſeſſes more of the properties of vitrifi earth.

Theſe principles, which are inconteſtable, being o underſtood, are eaſily applicable to the art of making gl as we ſhall ſhew: ſince, if we could produce a fire ſu ciently intenſe, and had furnaces and veſſels capable of taining it, we ſhould make glaſs equal to the preci ſtones; it is therefore evident, that the moſt import object in vitrification, is to have furnaces capable of p ducing the greateſt heat, and pots or crucibles capable reſiſting, during a long time, this heat, and alſo the act of the vitreſcent matter that they contain. At the article this Dictionary, CLAY and POTTERY, may be ſeen w are the beſt earths, or mixtures of earths, for the conſtr

ti

urnaces, and of pots or crucibles. We ſhall here
eat, that theſe pots ought to be made entirely of
refractory and pureſt clay, well waſhed and
from all ſandy, ferruginous, and pyritous matters,
d with a certain proportion of the ſame clay baked,
ded not very finely. The quantity of baked clay
ht to be mixed with the crude clay, to prevent
from cracking when dried, or when expoſed to
heat, is not abſolutely determined, but varies in
glaſs-houſes, according as the crude clay employed
or leſs fat, as it is called: but Mr. D'Antic,
of Phyſic, a very able chemiſt, and particularly
nt about every thing relating to the theory
ctice of glaſs-making, in an excellent Memoir
s ſubject, propoſes a very good method of aſcer-
the quantity of burnt clay that ought to be mixed
de clay in the compoſition for pots and furnaces.
thod conſiſts in mixing the burnt and crude clay
ent proportions, and in forming cakes of theſe
ixtures, each of which is one inch in thickneſs, and
hes in each of the other two dimenſions. When
kes have been ſufficiently and very ſlowly dried,
expoſed to a violent heat, till they become as hard,
tract as much in their dimenſions as they can,
to be then examined; and the cake, which has
a diminution of its bulk equal only to an eighteenth
made of the beſt proportions. According to the
thor, moſt clays require that the proportion of the
ould be to the freſh as four to five.

ovens and furnaces are different according to the
of materials to be vitrified. For experiments
ys, we know none better than the melting furnace
d at the article FURNACE, and which muſt be
vith charcoal. In large works wood or foſſil coal
, and the furnaces are ſo conſtructed that the flame
fuel circulates and burns within very intenſely.
furnaces vary much in different countries and glaſs-
and as a deſcription would not be very intelligible
figures, we ſhall refer the reader to other works in
heſe ſeveral furnaces are deſcribed and repreſented,
arly to the French edition of Neri's Art of Making
with Notes by Merret and by Kunckel, and to the
quoted Memoir of Mr. D'Antic. We ſhall here
in general, that theſe furnaces are placed under
d lofty buildings called *halls*; that they are covered
with

with a vaulted roof; and that they have no chimney, b
only lateral openings through which the melted glafs
drawn from the pots. Under thefe openings is built a ki
of platform or banquette, on which the pots containi
the glafs ftand, one of which is oppofite to each openin
In the middle of the furnace, below the banquette, i
fpace, a-crofs which iron bars are laid. In this fpa
which communicates with a large cavity below, called t
afh-hole, the fuel is placed. In thefe furnaces, whi
have not any chimney, as we have faid, the fire is neve
thelefs very intenfe. This intenfe heat is occafioned
the great capacity of the furnace, by means of which
ftrong draught of air paffes continually from the afh-ho
Befides, the flame, being vividly agitated by air, a
not being drawn out of the furnace by any chimney, c
culates in every direction within the furnace, and produc
a very violent heat. Moft glafs-houfe furnaces have al
hollow towers that communicate with the cavity of t
furnace, and which therefore encreafe the capacity of t
whole. In thefe the heat is not nearly fo intenfe as in t
furnace. They are employed to contain the *fritt*, or t
pieces of manufactured glafs that are to be annealed. Su
is the general difpofition of the furnaces of glafs-houfes.

The good condition of the pots and furnaces is, as we ha
obferved, the moft important and effential matter to be co
fidered in the operations of making glafs. Next to that,
the confideration of the kinds and proportion of the fluxe
Of thefe we may obferve two kinds, namely, the inflammab
and the faline. As we cannot obtain the pure inflammab
principle, we muft, when we intend that it fhould enter in
the compofition of glafs, chufe for this purpofe fome of t
earthy fubftances with which it is found naturally con
bined; and thefe are particularly metallic earths, which a
beft adapted for conveying phlogifton into vitreous con
pofitions: but all thefe earths are not equally fit for th
purpofe. All metals are compofed of an earthy matt
intimately combined with a fufficient quantity of the in
flammable principle to be very fufible, and, at the fam
time, very opake. Some of thefe metals, namely, tho
called *perfect*, are unalterable by fire, and cannot be en
tirely, or even partly, deprived of phlogifton: but as ever
metallic fubftance is incapable of uniting with earth
matters, while it retains its metallic ftate, therefore n
perfect metal can be vitrified. The cafe is different wit
thofe metallic fubftances, the phlogifton of which may b
burn

or otherwise destroyed. The earths or calxes of erhaps of all combustible metals, when not perfectly l of all their phlogiston, are capable of being reduced reous state, by means of their remaining inflam- rinciple. As they are not then in a metallic state, n facilitate the fusion of vitrifiable earths, may with these an intimate union, and reduce them to of perfect vitrification: but these phlogisticated of imperfect metals promote vitrification more or cording to their particular natures. Some of these, instance, tin, cannot be without great difficulty to that precise degree of calcination that is necess- vitrification; because the heat required for this deprives them of all their phlogiston, and renders a high degree refractory. Others, in whatever they be calcined, either retain too little phlogiston ufficiently fusible, although they still retain enough them color; or if they be not calcined so much as to ir fusibility, they cannot be melted but into opake so nearly in a metallic state that they cannot be ntimately with vitrifiable earths. Such, especially, earths of iron and of copper.

ll metallic earths, that of lead is fittest for vitrifica- This metal, which contains a large portion of on, is quickly deprived of so much of it, that it metallic state, and is easily melted into a transparent mass; but it has, at the same time, this remark- operty, that when once it has lost as much phlo- s is necessary to dispose it to vitrification, its calx retains as much of it as is necessary to give to it est degree of vitrescibility; and that it may be sooner d into vapors by the continued action of a very fire, than it can be changed into an earth totally isticated, and consequently refractory, like the of tin and of regulus of antimony. Besides, the earth of lead is one of these that retain the least All these qualities render it preferable to any other earth for the purposes of vitrification. The earth uth, which in the above-mentioned properties re- the earth of lead, may probably be employed with success: but as the calxes of lead are much more n than those of bismuth, the use of this semi-metal nown to manufacturers of glass.

hatever manner the calx of lead has been prepared, d it be really in a calcined and not in a metallic state,

ſtate, it may be uſed in vitrification. Accordingly, th grey calx, or aſhes of lead, maſſicot, red-lead, litharg ceruſs, and all the precipitates of lead, ſeparated fro acids by unmetallic intermediate ſubſtances, being mixe with ſand or any other vitrifiable ſtone, and expoſed to ſufficient degree of fire do always promote the fuſion of the matters, and form with them glaſſes more or leſs hard ar tranſparent, according to the ſtrength of the fire and th proportion of the ingredients.

The earth of lead conſtantly retains, as we have ſai enough of the inflammable principle to preſerve its fuſibilit When it is expoſed ſingly to the fire, it vitrifies with a ve moderate heat. It has more phlogiſton than is requiſi for its vitrification. The fuſibility, fluidity, and activit of this glaſs of lead, when pure, are ſo great, that it cann be contained in any crucible, all which it eaſily pervade therefore pure glaſs of lead is never made. But as th calx of lead has more phlogiſton than is required for i own vitrification, it may divide this exceſs of inflammab principle with any unmetallic earths with which it is mixe and thus may produce their fuſion and perfect vitrificatio The glaſſes formed by a mixture of calx of lead with u metallic earths have more conſiſtence, hardneſs, and le fuſibility, than pure glaſs of lead. The proportions of ca of lead and of ſand employed in theſe kinds of glaſs, are fro one part to two of calx of lead, to one of ſand, or of grou flints.

We may obſerve upon the ſubject of glaſſes that conta no other flux than phlogiſton or metallic earths, of lea or of any other metal, that none of them are perfect white, but are all more or leſs colored; becauſe phlogiſt is, as chemiſts know, the principle of colors. Second theſe glaſſes have a greater denſity or ſpecific gravity th any natural cryſtalline ſtone, all metallic earths bei heavier than any that are not metallic.

Thirdly, metallic glaſſes are generally ſomewhat l brittle, are leſs liable to be broken by the alterations heat and cold, and have more of a certain ſmoothneſs, as it were, unctuoſity, not eaſily to be deſcribed, than glaſ made altogether of unmetallic earths. Theſe properti can only be attributed to the inflammable principle, pretty conſiderable quantity of which is united with the As theſe latter qualities of glaſs are valuable, a certain qua tity of calx of lead generally enters into the compoſition

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ne glasses, which are distinguished from ordinary
the name *crystal-glass*.

n what we have said concerning the properties of
c earths in vitrification we may perceive, that the
alx of lead, or other metallic earth, enters into the
ition of any glass, the more fusible, soft, colored,
ase this glass is; and reciprocally. The colors given
by calxes of lead are shades of yellow.

he substances are the second kind of fluxes used in
ation: but all these substances are not equally fit for
rpose; not that they are not all very fusible, but for
reasons hereafter to be mentioned.

, neither the pure and disengaged acids, nor volatile
nor ammoniacal salts can be employed as fluxes in
ation, because none of these saline matters is suffi-
fixed. Their volatility is so great, that they may
lly dissipated by fire before they could act in any de-
on vitrifiable earth.

ndly, none of the neutral salts with basis of fixed
containing either vitriolic acid or marine acid, can
ployed as fluxes in vitrification. This proceeds, not
heir want of fusibility, or of the necessary degree of
but from the union of the acid and the alkali; which
rong, that they cannot act with sufficient force upon
substances, and particularly upon vitrifiable earth:
aline matters fit for vitrification are, *fixed alkalis*, ve-
and mineral; *nitres* with basis of fixed alkali; *sedat*
*lt* and *borax*; *fusible salt of urine*, or rather *phosphoric*

all saline matters, fixed alkalis, vegetable and mineral,
st frequently used in vitrification. These alkalis are
with a moderate heat; they are so fixed that they can
during a sufficient time the heat of ordinary vitrifica-
and they act powerfully upon flints, sands, and
vitrifiable stones. The proportion of alkali to sand,
er to make good glass, is, from one to two parts of
rmer ingredient, and two parts of the latter.

re produces in vitrification nearly the same effects as
alkalis, although it be a neutral salt, the alkali and
f which are united together nearly as they are in
on salt, which however does not produce in vitrifi-
similar effects. The remarkable difference in this
t betwixt these two salts, and betwixt the nitre and
triolic salts, must be attributed to the great affinity of
s acid to the inflammable principle; which affinity

is

is so strong, that when nitre is exposed to fire in vessels n perfectly close, the acid quits its alkaline basis to uni with the phlogiston of combustible matters, even thoug these be not sensibly in contact with it. Hence nitre ex posed during a certain time to the action of a strong fir is gradually alkalised, and then becomes capable of dissolvin very effectually vitrifiable earth. This alkalisation is pr duced so much more easily in most vitrifications, that th ingredients employed generally contain some inflammab matter. Common salt cannot be alkalised in this manne because it cannot be decomposed by the contact of inflam mable bodies, and therefore is not used in vitrifications but as vitriolic acid has a strong affinity with phlogiston we might be inclined to think, that vitriolic salts wit basis of fixed alkali, which also are never used in vitrificatio might perhaps be employed along with sand or other vitr fiable matters containing a larger proportion of phlogisto than the ingredients now commonly used do: but I do n know that any sufficiently accurate experiments have bee made on this subject.

Fixed alkalis or nitre cannot be formed into transpare glass by being melted singly; because these salts contain to little of the earthy principle; for they form true glass when they are mixed with a sufficient quantity of this prin ciple, as with sands and other earthy matters: but bora sedative salt, and the fusible salt of urine, may be melte without any earthy addition, into transparent vitreou masses; and hence we may conclude, that these salts contai a larger portion of the earthy principle than nitre or fixe alkali. They nevertheless very powerfully promote th vitrification of other substances. These salts are n employed in the manufacture of large quantities of glas because they are too dear. Borax is sometimes used f making small quantities of some particular kinds of fin glass.

Arsenic may be enumerated among vitrifying fluxes, it is fusible and vitrescible singly, and is also capable of pr moting the fusion of vitrifiable earths; for which purpo it is frequently employed as an ingredient in vitreous com positions. As arsenic partakes both of the metallic an saline properties, it probably acts in vitrification both as salt and as a metallic earth. The quantity therefore arsenic necessary to promote vitrification, is intermediat betwixt the quantities of calx of lead and of saline sub stances that are necessary for that purpose. But we mu

observe

that as arſenic is very volatile, a great part of it
n vapors upon the firſt application of heat, and that
tity remaining is always uncertain. Arſenic cannot
employed as the ſole flux for vitrifiable earth.
ve intend that a certain quantity of this matter
emain in the compoſition of a glaſs, one of the beſt
that can be uſed for this purpoſe, is at the ſame
add nitre to the ingredients of this glaſs; becauſe
ic uniting with the alkaline baſis of the nitre forms
ral arſenical ſalt, in which the arſenic is conſider-
d. But as this neutral arſenical ſalt is eaſily de-
d by contact of phlogiſton, therefore no calx of lead
r ſubſtance containing the inflammable principle
be mixed with arſenic in the compoſition of glaſs;
ound by experience, that this neutral arſenical ſalt
difficultly manageable in vitrifications, not only for
on now given, but alſo from the property it has of
lly corroding and pervading crucibles and pots;
mixtures I have found that it quitted the vitrifiable
th which it was mixed, and acted upon the crucible,
it penetrated and diſſolved. Theſe experiments
me to believe, that arſenic has a greater affinity with
an with vitrifiable earths; which I propoſe hereafter
ain further.

Mr. Pott's experiments, chemiſts know, that vitri-
calcareous, and argillaceous earths, each of which
ly unfuſible, do reciprocally promote the fuſion
other, when mixed together nearly in equal pro-
, and expoſed to a very violent heat; and that
eſe mixtures matters perfectly vitrified are formed.
ve do not know the cauſe of this ſingular fuſibility,
not determine whether it is produced by a phlogiſtic
ſaline ſubſtance, or perhaps by both.

es that contain no other fluxing ingredient than
ic matters or metallic earths, partake of the pro-
of theſe metallic earths; and alſo glaſſes that contain
ine fluxes partake of the properties of ſalts. The
or ſaline glaſſes, when pure and well proportioned
heavy, leſs denſe, harder, whiter, more brilliant,
rittle, than the glaſſes containing calx of lead: and
containing both ſaline and metallic fluxes do alſo
of the properties of both theſe ſubſtances. In gene-
ſſes too ſaline are ſoft, and eaſily ſuſceptible of altera-
the action of air and water; eſpecially thoſe in
alkalis prevail; which latter glaſſes are alſo liable
to

to be attacked by acids, as we evidently ſee from the properties of the vitrified matter that is made with an exceſ of alkali, for the preparation of *liquor of flints*. Glaſſe containing too much borax and arſenic, although at firſ very beautiful, do quickly tarniſh and become opake wher expoſed to air.

From what we have ſaid concerning the properties o fluxes, phlogiſtic or ſaline, we may know how to adjuſt th proportions of theſe to the ſand, or powdered flints, for th various kinds of glaſs. Thus if we require a glaſs tha is denſe, fuſible, and not ſaline, one part and a half of re lead or litharge may be mixed with one part of ſand, an fuſed together. If equal parts of ſand and of calx of lea be employed, a glaſs ſomewhat leſs denſe and harder will b produced.

If a glaſs be required of very little denſity, only ſalin fluxes muſt be employed. A glaſs of this kind may be compoſed of ſix parts of ſalt of tartar, or of potaſh, or of purified ſoda, mixed with eight parts of ſand or of flints; o of four parts of any of the above-mentioned alkalis, mixe with two parts of nitre or of borax, and eight parts of vitrifiable earth. Theſe glaſſes muſt be left long in the fire fo the reaſons hereafter to be mentioned.

When a cryſtal-glaſs is required which ſhall be of a intermediate quality betwixt the metallic and ſaline glaſſes it may be made from a mixture of one part of the above mentioned ſalts, one part of calx of lead, and two part of ſand or other vitrifiable earth. By varying the proportions of theſe ingredients, many different kinds of glaſſe may be produced, each of which may be good, if the quantity of each of the fluxes employed be proportionable to it vitrifying power. Several good receipts for glaſs, an factitious cryſtal, may be found in *Neri's Art of Making Glaſ* with *Notes by Merret and Kunckel*, to which work we refe for many intereſting particulars. We ſhall however obſerve that the proportions of the fluxes neceſſary to produce an required kind of glaſs cannot be preciſely aſcertained, fo the following reaſons.

Firſt, the ſands, flints, and other ſtones commonly employed for making of glaſs, are not all equally fuſible Thus the quartzoſe ſand obtained by waſhing an eart found near Nevers, known to manufacturers of glaſs and o pottery by the name of *ſand of Nevers*, may be almo entirely melted when expoſed to a good vitrifying heat and by a moderate heat its grains may be conſiderabl

rounded

I know ſome other hard ſtones, which in a vio-
are ſtill more fuſible, and convertible into an almoſt
nt glaſs without addition. The fuſibility of theſe
e ſtones is cauſed by ſome unknown heterogeneous
nited with them. Theſe fuſible ſands and ſtones
much leſs quantity of flux to promote their vitri-
than other ſands or vitrifiable ſtones, which are
rer, and therefore more refractory.

lly, although the phlogiſtic and ſaline matters
as fluxes in vitrification are ſufficiently fixed to
he degree of fire neceſſary for the fuſion of glaſs,
nevertheleſs far from being ſo fixed as vitrifiable
The fire neceſſary for the perfect fuſion of glaſs, is
icient to evaporate them entirely. Accordingly,
houſes where the pots are uncovered, a vapor
continually riſes from their ſurface, which is
elſe than the ſaline and phlogiſtic fluxes in a ſtate
ual exhalation. Hence the longer glaſs remains
the fire, the harder and more difficultly fuſible
es, and the more it partakes of the properties of
fiable earth. Accordingly, even when a very hard
quired, ſuch a quantity of flux ought to be added,
t firſt promote a perfect fuſion; and this fuſion
be continued a long time till a conſiderable quantity
x is gradually diſſipated, and till the glaſs has ac-
e requiſite degree of hardneſs, provided that the
fficiently ſtrong to maintain the fuſion notwith-
the loſs of flux. From theſe obſervations it
that we cannot preciſely aſcertain the proportion
vitrifiable earth, unleſs we knew the fuſibility of
o be employed, and the degree of heat which can
in the furnace.

line fluxes, and eſpecially the fixed alkalis em-
vitrification, are generally rendered impure by a
f ſeveral heterogeneous matters, and eſpecially by
lts not vitrifiable, and by a certain quantity of in-
principle. In manufactories of bottles and other
glaſs, the alkalis employed are not previouſly
but are even mixed with the earth of the aſhes of
plants, which earth is alſo much diſpoſed to
on. Accordingly, to make glaſs of this kind,
ixed with common wood-aſhes, ſometimes even
which have been lixiviated, togeth with ſome
potaſh, ſoda or kelp; and from this mixture a
uſky, not very tranſparent glaſs is produced,

 which

which is preferred in common ſale for wine bottles t
clearer and more tranſparent glaſs. But when a fine, whit
and very tranſparent glaſs is required, the alkali muſt b
perfectly purified from all heterogeneous matter, b
lixiviation and calcination. *See the articles* ALKA
(FIXED).

As a too large quantity of the inflammable principle is t
chief cauſe of the colors and of the opacity of glaſs, wh
a perfect colorleſs and tranſparent glaſs is required, n
only the alkalis muſt be deprived of all their ſuperabunda
phlogiſton, but alſo the ſands or flints employed muſt
purified from any of this principle which they may contai
The method uſed for this purpoſe is by mixing togeth
the due proportions of ſands and ſalts, by expoſing t
mixture during a conſiderable time to a red heat, not inte
enough to melt it. By this calcination, the phlogiſt
of theſe matters is burnt and diſſipated, all color is d
ſtroyed, and the glaſs produced is alſo more clear and br
liant. This firſt mixture of materials of glaſs, when ca
cined, is called *the fritt*; and this fritt is uſed in lar
manufactories not only for the finer glaſs, but alſo for t
common brown glaſs; not with an intention to render t
latter kind of glaſs colorleſs, but becauſe during, this ca
cination, the ſalts and earth begin to act upon each oth
and to incorporate in a certain degree; by which a gr
part of the effervescence and ſwelling occaſioned by t
reaction of theſe matters, which happen when they are
once expoſed to a melting heat, are avoided. According
when matters not previouſly fritted are employed in ſm
experiments, the heat muſt be applied gradually; otherw
they ſo ſwell, that frequently the greateſt part of the mixtu
runs over the crucible.

The due degree of heat is an eſſential point in making
glaſs; it ought not only to be very ſtrong, but alſo ma
tained during a long time. In great manufactories, t
glaſs is kept fuſed during ten or twelve hours before it
taken out of the pots. Accordingly their glaſs is alwa
more perfect than that which is haſtily made in ſm
quantity in two or three hours. Good glaſs, althou
kept in fuſion in a very great heat, is not perfectly liqu
It is always ſomewhat thick, and when taken from t
crucible, it may be drawn out into fine wire or threa
which ſhews that it has a certain conſiſtence and a v
ſenſible tenacity when it is red-hot. It is not tranſpare
while it remains red-hot, not even when it has become p
fec

hard. Another remarkable circumſtance is, that which is ſo brittle when it is cold and tranſparent, is uctile when it is ſo heated as to be opake. We might uced to believe, that the diſengaged fire with which aſs is filled when it is red-hot, produces upon it the effect that phlogiſton, or combined fire, produces netals. The ductility of red-hot glaſs is very uſeful; its means all imaginable ſhapes may be given to glaſs, umberleſs veſſels and utenſils may be eaſily formed

oon as glaſs-veſſels have received their intended form, muſt be cooled very gradually, otherwiſe they would o ſolidity, and would be of little uſe, as they would ble to be broken by the ſmalleſt ſtroke, or by a change of heat and cold. This inconvenience is pre- in glaſs-houſes by carrying the glaſs veſſels as ſoon are formed, and while yet red-hot, into an oven too eated to deſtroy their form, but in which they may be radually cooled. This is called *annealing* the glaſs. withſtanding all the care taken in the manufactories iner kinds of glaſs, as cryſtal-glaſs and plate-glaſs, to them perfectly good, they are nevertheleſs ſeldom quite free from faults. The principal faults in glaſs olors, bubbles, and veins. The colors which gene- urt glaſs, eſpecially that kind which contains ſaline are ſhades of green, olive, and blue. Theſe colors troyed by *manganeſe*, which being added in ſmall ties, clears the glaſs, and is therefore called by artiſts *of glaſs*. This effect of manganeſe cannot eaſily be ed, for it has the property of tinging glaſs with a color. Mr. Montamy, in his *Traité des Couleurs Peinture en Email*, has a very fine and ingenious t upon this ſubject, which is, that the manganeſe s the above-mentioned colors, by adding to theſe le tinge, and by the mixture producing a blackiſh- color; and that as blackneſs is cauſed merely abſorption of the rays of light, therefore the h tinge given to the glaſs by the above mixture of prevents the reflection of ſo many rays, and thus the glaſs leſs colored than before. The cauſes of bles and of the veins in all glaſs, even when moſt ly prepared, and the methods of preventing theſe are little known. No reſearches have been made his ſubject, by any chemiſt excepting by Mr. D'Antic, experiments are publiſhed in the Memoirs of the Aca-

demy. But however interesting these may be, this mat requires further examination. As the veins of glass, unl they be considerable, are seldom very perceptible in the fi kinds of glass when well compounded, and carefully ma they have therefore been hitherto neglected. Neverthel we ought to inform those who are interested in the progr of arts and sciences, that since the important discovery achromatic telescopes has been made, the correction of t fault in glass deserves attention. We need only info those who would attempt this improvement of glass, that t object-glass of these telescopes is composed of several glas of different degrees of density; and that the effect of t composition of different glasses is (supposing them at t same time to have the due curvatures), that telescopes m be made, which do not exhibit irises when looked throug which are therefore infinitely preferable to ordinary te scopes, and from which athronomy may receive much a vancement.

Some great geometers have determined the density a the curvature that these object-glasses ought to have. B in vain have Euler, Clairaut, and D'Alembert illustrat this part of dioptrics by means of the most sublime theor unless glasses can be made which shall be capable of pr ducing the effects required. No certain and constant m thod is yet known for making crystal-glass for this purpo A celebrated English optician, Mr. Dollond, who h himself had a considerable share in the discovery of the new telescopes, does indeed make them very good *(d)*. B

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*(d)* The indistinctness of the images seen through comm telescopes proceeds chiefly from this cause, that some of the c lored rays of light are refracted more in passing through glass, an refracting medium, than the others, and do therefore pr duce prismatic colors. The late ingenious Mr. Dollond foun that this difference of refrangibility or dispersion of the color rays, was much greater when the rays passed through some kin of glass, as flint-glass, than through others, as crown-glass. I adding, therefore, to the convex object lens of telescopes (whi was made of crown-glass) a concave lens made of flint-glass, t curvature of which was not sufficient to destroy the whole conve gency of rays of light produced by the convex lens, he counte acted the error proceeding from the dispersion of the colored ra in passing through the convex lens, and, by thus uniting the several rays, formed one distinct image. This power of differe kinds of glass, by which they disperse the colored rays is not pr

po

opticians, who procure from England the ſame glaſs t is employed by the Engliſh opticians, affirm that this ſs is very faulty; and that amongſt a large quantity, e pieces only can be found fit for the purpoſe: hence find that it is not conſtantly made good in the Engliſh ſs-houſes.

tionable to the denſity of the glaſs; although calx of lead ed to glaſs ſingularly encreaſes this diſperſive power. The hor of the Dictionary ſays, that Mr. Dollond had a great e in this diſcovery. He was the firſt perſon who attempted or executed this improvement. We may indeed obſerve, that g before, in the year 1713, Dr. David Gregory, the celebrated feſſor of Aſtronomy at Oxford, did ſuggeſt, (in his *Catoptricæ Dioptricæ Sphericæ Elementa*) that by compounding the object s of a dioptric teleſcope of ſeveral media of different refractive vers, the image might be rendered more diſtinct, in the ſame nner (ſays he) as it is done by the compounded media of the s of animals.

Mr. Zieher of Peterſburgh has made experiments which ſhew, t by encreaſing the proportion of red-lead to flints in the com- tion of glaſs, he could greatly encreaſe this diſperſive power proportion to the mean refraction; and that by adding alkaline s to the mixtures of calx of lead and flints, he could greatly iniſh the mean refraction of his compoſitions without leſſening ir diſperſion. He ſays he compoſed a glaſs much ſuperior to t-glaſs, as its diſperſive power was much greater relatively to its an refraction. But this is not the principal difficulty in making ſs fit for achromatic teleſcopes. The flint-glaſs commonly made England, with a ſmall proportion more of calx of lead in its com- ition, would ſufficiently anſwer the purpoſe of opticians, if t glaſs could be procured free from veins. But here lies the iculty that has hitherto obſtructed the advantages which we l reaſon to expect from Mr Dollond's excellent diſcovery. fortunately, this kind of glaſs is peculiarly ſubject to ſmall ns, which diſturb the rays in their paſſage, and thereby render viſion confuſed. This effect is owing to the denſity of theſe veins ng greater than that of the reſt of the glaſs, as appears from ir image received on white paper, when the glaſs is held be- een the paper and a candle, or other luminous object. For this age of a vein, thus received, is a line brighter than the reſt of image of the glaſs, and this bright line is defined by a dark ge on each ſide. But the bright line evidently ſhews a conver- ncy of rays, and this convergency can only be effected by the ns being denſer than the medium in which they are placed. e reaſon why flint-glaſs is more ſubject to veins than any othe ſs, is (as I apprehend) becauſe it is compoſed of materi re different denſities.

A certain method therefore of making ſuch a cryſtal gla as is required, ſtill remains to be diſcovered. Two kinds glaſs are required for the object-glaſs of achromatic tel ſcopes. One of theſe is a light cryſtal-glaſs, made wi ſaline fluxes, like the French mirror-glaſs.

Good pieces of this kind of glaſs may be eaſily foun The other kind of glaſs is a denſer cryſtal-glaſs, and ther fore contains ſome calx of lead in its compoſition. Such the Engliſh flint-glaſs. The denſity of this glaſs oug to be ſuch, that a cubic inch ſhall weigh fourteen hundr grains. A perfect glaſs of this kind cannot be obtain without great difficulty. I have been aſſured by ſome int ligent perſons, who have conſidered this ſubject of achr matic teleſcopes, that the qualities eſſentially requiſite this glaſs were, that it ſhould be very tranſparent, and p fectly free from veins, to which it is very liable; and tha ſlight tinge of yellow, and even a few bubbles, were not v injurious. I have made many experiments to obtair cryſtal-glaſs free from veins, but have met with great di culties. The veins are undulated, like thoſe which app when two liquors of different denſities, as water and ſp of wine, are added together, and before they are w mixed. This appearance ſhews, that ſomething ſimi happens in the making of glaſs. I endeavoured to cor this fault by a very careful mixture, and by a compl fuſion. But I confeſs, that although I have expoſed th glaſſes to very violent and long-continued fires, and h ſeveral times pulveriſed and ground them, and repeated fuſion, I have not been able to procure any perfectly from veins. I have been prevented by other neceſſary oc pations from continuing my experiments on this ſubj But although thoſe which I have made, ſufficiently ſhew difficulty of making glaſs of the required denſity, and wh ſhall be perfectly free from veins, this difficulty neverthe does not appear unſurmountable; and I do not doubt that by patiently proſecuting this inquiry, we may arriv the deſired ſucceſs.

We ſhall obſerve, in concluding this article, that ſev cauſes leſſen, or entirely prevent the tranſparency of gl which is one of its moſt neceſſary qualities. As we car melt vitrifiable earth into tranſparent maſſes but by m of fluxes, and a ſufficiently ſtrong and long-continued h therefore when the vitreous mixture contains too l flux, or is expoſed to too little heat, ſome parts of the v fiable earth cannot be entirely fuſed, and therefore in

ore or leſs, according to their quantity, the tranſparency the glaſs. The ſame fault may be perceived in glaſs, hen it contains ſome earthy matter not ſuſceptible of the tion of fluxes, as vitrifiable earth is; ſuch as, for inſtance, oſt metallic earths that are too much dephlogiſticated, rticularly the earth of tin. Accordingly, theſe earths e employed to make opake or ſemi-tranſparent glaſſes, as amels, artificial opals, and other ſuch ſtones. Another mark may be made concerning the tranſparency of ſome nds of glaſs, that is deſtructible by a too long expoſure violent heat. As all fluxes, phlogiſtic or ſaline, are uch leſs fixed than vitrifiable earth; and as ſome fluxes e leſs fixed than others, or leſs capable of becoming fixed being mixed with vitrifiable earth; the cauſe therefore the loſs of tranſparency which ſome glaſſes ſuffer by a o violent fire, is, that a part of their flux is diſſipated, ſo at theſe glaſſes are decompoſed, and that they contain ſo uch earth that the flux is incapable of keeping them com- eatly fuſed. I have obſerved that glaſſes formed by a ixture of argillaceous, and gypſeous or calcareous earths, e more liable than any others to this loſs of tranſparency. *e* ALKALI, EARTH, FURNACES, *and ſeveral other articles lating to vitrification.*

VITRIOL. This name is particularly applied to ree neutral vitriolic ſalts with metallic baſes. Theſe ſalts e, 1. The combination of vitriolic acid with iron, called *artial vitriol*, *Engliſh vitriol*, *green vitriol*, or *green copperas*. The ſalt reſulting from the union of the ſame acid with opper, called *vitriol of copper*, *blue vitriol*, *Cyprian vitriol*, *blue copperas*. 3. The ſalt compoſed of vitriolic acid with nc, called *vitriol of zinc*, *white vitriol*, *white copperas*, and *oſlar vitriol*.

We have obſerved under the articles *vitriolic acid* and *ſalts*, at the name *vitriol* ought to be applied to all vitriolic ſalts ith metallic baſis. Thus, for inſtance, the ſalt compoſed f vitriolic acid and gold may be called *vitriol of gold*; and e ſalt formed by the union of this acid with ſilver may be lled *vitriol of ſilver*, or *lunar vitriol*. Perhaps all vitriolic lts might be conveniently comprehended under the general ame *vitriol*. The properties of vitriolic ſalts are men- oned at the articles, ACID (VITRIOLIC), ALKALIS, ARTH (CALCAREOUS), SALTS, SELENITES, GYPSUM, LABASTER, SPAR, SMELTING *of* ORES, *and of the ſeveral etallic ſubſtances.*

UMBER. *(c)*

VOLATILITY. Volatility is a property that ma bodies have of being reduced into light vapors, which exh when they are exposed to the action of fire. This qual is opposed to *fixity*. The cause of it is, the greater or l *dilatability* which bodies have when exposed to fire. P haps every body is, rigorously speaking, volatile: but there are some the volatility of which can be only render sensible by the action of a fire much more violent than a which we can produce, we consider these bodies as bei fixed, or not volatile. *See* FIRE *and* FIXITY.

URINE. As urine is an excrementitious animal liqu it contains only such principles as are useless or hurtful the animal economy; and is accordingly found to be n thing but a lixivium of different saline substances, whi cannot enter into the composition of an animal body, gether with a quantity, not very considerable, of a sapon ceous, extractive, and very putrescent matter. In ur we find none of the gelatinous substance that is contain so copiously in other animal liquors that are not excreme titious; for this gelatinous substance, as we have said un the article JELLY, is the principal constituent, nutriti and reparative part of animal bodies, and could not the fore, without some considerable fault or disorder in the anim economy, be rejected with any excrementitious matt The urine of healthy animals is therefore nothing bu serous saline liquor, that may be entirely evaporated, wi out shewing any gelatinous matter.

The fresh urine of healthy animals is transparent, a something yellowish or citron-colored, has a slight smell, saline nauseous taste, and does not change the color of syr of violets to a red or to a green: but this liquor var considerably when the animal economy, and especially digestive organs, are disturbed. Accordingly, physici carefully observe the urine of their patients; but althou

*(c)* UMBER. Is a fossil substance, so called from *Ombria*, ancient name of the district of Spoleto in Italy, whence it w first brought. M. le Baron de Hupsel has discovered it to b fossil wood, filled with a bituminous juice. *Berlin Mem.* 1 This substance is found in two different states, first, as retaini the form of wood, which it has preserved by means of a bitu nous matter that has prevented the rotting of the wood; a secondly, as a powder, like that into which the first kind, t still retains the form of the wood, easily crumbles

often receive much assistance from such observation, a dangerous error that quacks lead many ignorant per- into, to believe, that by the mere inspection of urine diseases may be discovered. Physicians, who have passed r lives in an attentive observation of the signs of diseases, too sensible of the insufficiency of every aid to decide ainly concerning the nature of many diseases. But this ction ought to be a motive to inquire into the various nges that urine undergoes in different states of the body, e accurately than has been hitherto done, especially as improvements daily made in chemistry may give us es of throwing more and more light upon this and other resting subjects.

The qualities of urine are very apt to vary considerably, n without any very perceptible derangement of the animal nomy. For instance, it is sometimes much more copi- than at other times. This difference of the quantity rine has been observed to depend much on the quantity erspiration and of sweat that have been exsuded at the e time; for the nature of these fluids is very similar to of urine. Generally, when the urine is in small quan-, it is deeper colored: and reciprocally.

The urine of persons afflicted with hysterical and melan- lical spasms is frequently copious, limpid, and purely ery or serous, without color or smell. This urine is ed *crude urine*. The same persons do also frequently harge urine in small quantity, that is high-colored, that a strong smell, and that quickly becomes turbid when osed to cold. We may observe, that the sediment ch renders this urine turbid may be again redissolved by e fresh and warm urine, and is therefore of a saline na-.

Certain odoriferous substances, taken internally, as tur- tine, asparagus, and others, are well known to com- nicate quickly their smell to urine, even in perfect health: I have also seen persons subject to pains of the head and bad digestion, proceeding from a melancholic or hysteri- temperament, who discharged urine, in which I could dently perceive the smell of coffee, spices, onions, fruits, ts, and even of broth, and other aliments. The urine of se persons was habitually acid, reddened syrup of violets blue paper, when it was recent, and especially after ing fruits and roots, or drinking even a very small quan- of wine.

From

From these two latter observations we may perceive, urine depends much on the state of digestion, the f of which may therefore be discovered by examining liquor.

Urine is strongly disposed to putrefaction. In te twelve hours, when the weather is warm, it acqui strong smell; and in great heats, this smell may be perc in five or six hours. The beginning of the putrefa of this liquor may be perceived by a putrid, disagree but not pungent smell. The smell afterwards bec pungent, and discovers a volatile alkali, which is very piously disengaged in the putrefaction of this liquor. though the disagreeable smell that is perceived at fi urine beginning to putrefy has not the pungency of vo alkali, it nevertheless seems to be produced by this salt by mixing any acid with urine in this state, its fetid is immediately destroyed. By the same means also smell of vessels in which urine has been contained ma destroyed. On the contrary, by mixing some fixed a or quicklime with fresh urine, a pungent smell of vo alkali and of putrid urine is instantly produced. As i short a time no real putrefaction can happen, we mus tribute the discharge of volatile alkali in this experime a decomposition of a sal ammoniac, which is contain the freshest urine, as we shall soon shew.

If the fresh urine of a healthy person be distilled in vessels, nothing is obtained from it with the heat of bo water, but a pure phlegm with a slightly nauseous s This phlegm is generally ⅞ parts or more of the whole u but the quantity of this and of the other principles of are very various.

As nothing but phlegm is separated at first in this dis tion, when therefore urine is to be analysed, the oper may be accelerated and simplified by evaporating it ove fire in an open vessel. We may then observe, that the phlegm of the urine is evaporated, the remaining li becomes turbid, and deposites a certain quantity of m which is almost entirely earthy. The quantity of earth varies also according to the nature of the urine deserves a particular examination. The observatio Mr. Herissant, Physician of the Faculty of Paris, and M ber of the Academy of Sciences, concerning the uri several persons afflicted with diseases in which the bones affected and wasted. *See Memoirs of the Academy for th* 1758; and those also of Mr. Morand, of the same Fac

nd Member of the ſame Academy, concerning the urine of woman whoſe bones were entirely ſoftened by the loſs of eir earthy matter, which was found to contain a conſiderble quantity of earthy ſediment; ſhew, that the earthy diment of urine, which is firſt depoſited by evaporation, partly at leaſt of the ſame kind as the earth of bones; nd that in a healthy ſtate, nature throws off, by the urinary aſſages all the earthy matter that is not required for the ncreaſe or reparation of the bones. This earthy ſediment ppears alſo in putrid urine.

While the urine evaporates, the remaining part of it equires a more and more deep brown color, by the approxiation of the ſaponaceous extractive parts which it conains. When, by evaporation, it has acquired the conſtence of a clear ſyrup, or of freſh cream of milk, it ought be put in a cool place, that the ſeveral neutral ſalts which contains may be cryſtallized. The firſt cryſtals that are btained are a particular kind of ſalt known to chemiſts by e names, *native* or *eſſential ſalt of urine*, *fuſible ſalt of urine*, *hoſphoric ſalt*, and *microcoſmic ſalt*. This ſalt contains the cid proper for making phoſphorus. Some part of this ſalt as a baſis of volatile alkali, and is therefore a kind of amoniacal ſalt; and the reſt has a baſis of fixed alkali. *See* ALT (FUSIBLE) *of* URINE, *and* PHOSPHORUS *of* KUNCEL. When the urine contains any ſalts that are more yſtallizable or leſs ſoluble than the fuſible ſalt, as it freuently does, ſuch as ſelenites, vitriolated tartar, and thers, theſe are firſt cryſtallized, eſpecially if they be in onſiderable quantity. *See* CRYSTALLIZATION.

By alternately evaporating and cooling the liquor, the ther leſs cryſtallizable ſalts, ſuch as common ſalt, a great uantity of which urine generally contains, may be ſepaated. In the urine of different animals all the neutral ſalts re generally found which they have taken, either along vith their aliments or otherwiſe; becauſe theſe ſalts, not eing uſeful in the compoſition of animal matters, after aving circulated ſome time in the blood veſſels, are carried ff, unchanged, along with the urine.

After all the neutral ſalts have been obtained from urine, othing remains but a brown, ſaponaceous, extractive matter, vhich forms a kind of mother-water. This matter yields, vith a naked and graduated fire, a conſiderable quantity of olatile alkali, both fluid and concrete, together with ſome etid animal oil. With the utmoſt violence of fire, a ſmall uantity of phoſphorus may alſo be obtained; and a little common

common ſalt may be ſeparated from the reſiduous coal. T
phoſphorous is produced by a little fuſible ſalt which
not ſeparated by cryſtallization, but remained, toge
with the above-mentioned ſmall quantity of common
diſſolved in the liquor.

From this analyſis of urine we may perceive, that
compoſed of a large portion of pure water, in which is
ſolved a conſiderable quantity of earthy matter, that fo
the ſediment of urine; of two phoſphoric ſalts, one
which is ammoniacal, and the other has a baſis of f
alkali; of common ſalt; and, laſtly, of a ſaline ſapo
ceous matter, which contains a combined oil. In urine
gelatinous matter nor uncombined oil are found.

Such is the ſtate of our preſent knowledge conce
ing the nature and principles of urine. It certainly
capable of receiving much addition from future inqui
by which medicine might be much improved; but we m
at the ſame time, confeſs, that we cannot receive all
knowledge we wiſh upon this ſubject without very long
laborious operations. The moſt important point to
known is the compoſition and proportions of the ſev
conſtituent parts of urine: but, as we have already
marked, theſe are very variable, according to the ſtate
health or of ſickneſs, to the differences of conſtitutio
aliments, exerciſes, diſeaſes, medicines, and perhaps e
to the variations of the atmoſphere. A knowledge of
differences of the urine in all theſe ſeveral circumſtance
very important, but can only be acquired by a long
zealous obſervation of thoſe phyſicians who are inſtru
in the ſeveral ſciences relative to their profeſſion.

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WAND (DIVINING). The divining wand
an inſtrument, by means of which many perſ
have formerly pretended, and ſome do now pretend, to
cover under what parts of the earth metals, treaſures, o
water, ſalt, &c. lie hid, without digging the grou
They ſay, this diſcovery may be made by a perſon hold
the wand horizontally, and by walking along in pl
where theſe matters are expected; and that when he
rives at a place under which any of the above-mentio
matters lie, the wand will be forcibly inclined towards
pla

place: but that this experiment ſhould ſucceed, much faith ſeems to be required in the perſon who holds the wand, or rather in the ſpectators. We may eaſily perceive, that the power of this wand is a chimera, which owes its reputation to avarice, to ignorance, and to credulity.

The famous Father Kircher, in his *Mundus Subterraneus*, in which many intereſting particulars are found concerning mines, juſtly derides theſe ſuperſtitious practices, and denies, from his own experience, the truth of the aſſertions concerning them. He ſeems, however, to have ſome faith in ſympathies, and propoſes even new divining wands of his own invention; the effects of which, though more dependant on phyſical cauſes, are not however more certain. He believes, for inſtance, that a wand, one end of which ſhould be made of ſal gem, and the other of wood, being ſuſpended and balanced above a mine of ſalt, would be inclined towards the ground; and he ſupports his opinion by an experiment. This experiment conſiſts in evaporating over the fire a ſolution of ſal gem, below the wand, which is by this means really made to incline. We need not be deeply learned in chemiſtry to diſcover, that the wand would have inclined in the ſame manner, if Father Kircher had evaporated pure water inſtead of a ſolution of ſal gem; becauſe the water would have equally well attached itſelf to the ſaline end of the wand; conſequently this experiment proves nothing.

The ſame author propoſes alſo to diſcover mines of mercury by employing a wand, one end of which is made of gold, and the other of wood, in hopes that the emanations of the mercury would attach themſelves to the gold rather than to the wood, and would make it incline downwards. But this effect certainly cannot be produced unleſs the mercury was evaporating; for which purpoſe two conditions are neceſſary: 1. The mercury muſt be in a native metallic ſtate, and not mineraliſed, as it is in cinnabar; and, 2. It muſt alſo be expoſed to the heat of ſome ſubterranean fire, by which it is volatiliſed and ſublimed, the ordinary heat of the earth being far too little for this purpoſe. This ſecond phyſical or chemical divining wand propoſed by Father Kircher is therefore no better than the former; and probably the ſame judgment may be paſt upon all other wands made upon the ſame principles, and in imitation of theſe. Laſtly, the ſame author poſitively affirms, that he hung and balanced a wand, one half of which was made of alder-tree, and the other half of ſome wood that has no

ſympathy

ſympathy with water, over a ſubterranean water, and t
he obſerved the end of the wand, which was made of ald
incline towards the earth.

WATER. Water perfectly pure, (for of ſuch o
we treat in this article) is a tranſparent body, with
color, without ſmell, and without taſte.

Water is very volatile, and ſo very fuſible, that it
conſtantly liquid with a leſs degree of heat than is requi
for vegetation: hence it is generally conſidered as a liqu
But when it is expoſed to a leſs degree of heat, it becon
ſolid, like all other bodies naturally ſolid, which reſu
their ſolidity when they are no longer expoſed to a h
ſufficient to keep them in fuſion.

When water, that is expoſed to a degree of cold ſu
cient to render it ſolid, paſſes from a fluid to a ſolid ſta
this change is called the *congelation* or *freezing of wat*
and the water thus rendered ſolid is called *ice*.

When water is frozen with all the circumſtances neceſſ
for the free arrangement of the integrant particles of bod
(which circumſtances are explained under the article CR
STALLIZATION), it aſſumes determinate and regular forn
M. de Mairan, in his excellent Treatiſe on Ice, has det
mined, that theſe regularly formed maſſes of frozen wa
are like needles croſſing each other, or rather infixed i
each other, ſo as always to form two angles, one of whi
is equal to ſixty degrees, and the other equal to a hund
and twenty degrees.

This regularity in the congelation or cryſtallization
water ſhews, that it is a body not much compounded. W
ſhall ſoon ſee that it is one of the ſimpleſt of all known bodi

Water is not compreſſible. This truth is aſcertain
by a famous experiment, which conſiſts in including wa
in a hollow ſphere of metal hermetically cloſed, and in e
poſing this ſphere to a very ſtrong compreſſion, by whi
means the water is forced through the pores of this metal
ſphere rather than ſuffer any compreſſion. *(f)*

*(f)* The validity of the inferences drawn from this expe
ment, called the *Florentine experiment*, has been juſtly queſtione
An ingenious philoſopher, Mr. Canton, has proved, by expe
ments ſhewn to the Royal Society, that water is actually co
preſſed by the weight of the atmoſphere. The diminution of fi
that water ſuffers when it paſſes from a greater to a leſs degree
heat, till it begins to freeze, ſufficiently ſhews, that the int
grant parts of this fluid are, like thoſe of all other known ſu
ſtances, capable of approximation.

T

The ſpecific gravity of water, compared with that of air, in a temperature intermediate betwixt the greateſt ſummer heats and the greateſt cold of winter, has been determined by the beſt experimental philoſophers to be nearly as 850 to 1; that is to ſay, that any given bulk of water is 850 times heavier than an equal bulk of air.

We have ſaid above, that water is a very volatile body. It is entirely reduced into vapors and diſſipated, when it is expoſed to the fire, and is not confined.

When water is heated in an open veſſel, and is unconfined, it has been obſerved to acquire no more than a certain determinate degree of heat, whatever be the intenſity of the fire to which it is expoſed; which greateſt degree of heat is that which it has when it boils quickly. This degree of heat, and alſo that degree at which water begins to freeze, are fixed and determinate, and are therefore very uſeful in many chemical and phyſical experiments. By means of theſe fixed points of heat, we have been enabled to conſtruct thermometers, which may always be compared one with another; and we have alſo been enabled to apply preciſe and determinate degrees of heat, which are neceſſary in many chemical operations. *See* BATH (WATER).

Some philoſophers have ſaid, that the property which water and ſome other bodies have, of acquiring only a determinate degree of heat, proceeds from the rarefaction cauſed by this degree of heat, by which means the fire penetrates them freely and without any reſiſtance. *See* FIRE. But this opinion is erroneous. The cauſe of this phenomenon evidently is, that water being volatile, is reduced into vapors which are conſtantly exhaled and removed from the fire, the action of which they elude as ſoon as they ſuffer a certain degree of heat, as may be proved by the following conſiderations.

Firſt, none but volatile bodies have this property; bodies abſolutely fixed being capable of acquiring indefinite degrees of heat: hence the more volatile a body is, the leſs heat it can require, and reciprocally; or, to ſpeak geometrically, the degrees of heat which bodies expoſed to the action of fire, and unconfined, can acquire, are inverſely as their volatility, and conſequently directly as their fixity.

Secondly, when water and all volatile bodies are expoſed to the action of fire, and ſo confined that they cannot freely evaporate or elude that action, they are then capable of acquiring a degree of heat that is much more conſiderable, is

is indeterminate, or rather proportionable to the force which they are confined, and prevented from evaporat

We have an obvious example of this in the effec *Papin's Digester*. Water being confined in this vess that it cannot evaporate, is capable of acquiring a de of heat much greater than that with which it boils in c air, and even sufficient to make it red-hot.

Besides, it has been observed, that the mere variatio the weight of the atmosphere makes a greater degre heat to be requisite for the boiling of water in open ves at sometimes than at others: for the heavier the ai the greater heat is required to make it boil.

M. Pærner observes, in his notes to the German edi of this Dictionary, that the degree of heat which bo are capable of receiving, is relative to their particular ture, according as it partakes more or less of the infl mable principle; and he cites, as an instance, the essen oil of turpentine, which, although it be more volatile t water, is nevertheless, according to him, capable of ceiving, by boiling in open vessels, a greater degree of than that of boiling water. From thence we ought to c clude, that the determinate degree of heat which bo can receive, when exposed to heat in open vessels, is proportionate to their volatility or fixity. In answer to t I observe, that I much question the truth of the alled experiment, which, however, I have not made, and wh is not very easy to make on account of the inflam bility of the oil of turpentine, and of the insupport and dangerous vapors which are exhaled, when a suffic quantity of this and other essential oils are heated t certain degree in open vessels. I therefore doubt mu whether the experiment has been made with due care attention, and I cannot but consider it as false, becaus is contrary not only to theory, but also to all the analog experiments which have been made on this subject.

It is true, that all bodies exposed to the same heat, not with equal ease, and in the same time, become equa hot. Several good philosophers, as Dr. Franklin and Buffon, have proved, that metals are more quickly hea than stones. The disposition to receive heat quickly see to be a property of substances which contain the princi of inflammability. Franklin therefore considers these su stances as conductors of heat; and the oil of turpenti like other inflammable matters, ought to receivce heat m *quickly*, than liquors which do not contain the inflamma

princi

principle. But we ought not thence to infer, that it can receive *more heat*. The property of receiving much heat, and that of receiving it quickly are very different; but M. Pærner ſeems not to have attended to this diſtinction. Thus mercury becomes hot more quickly than ſand, but is not capable of receiving ſo much heat.

Upon this ſubject we muſt obſerve, that when water, or other volatile bodies, are thus expoſed to a greater degree of heat than is ſuited to their volatility, they are in a violent ſtate; and are therefore apt to break any veſſels that confine them, with an exploſion ſo much more violent, as they are more ſtrongly compreſſed, and are expoſed to a more violent and more ſuddenly applied heat.

Hence we may conceive why water expoſed to heat, too ſuddenly to allow it to evaporate, gradually occaſions terrible exploſions; as, for inſtance, when water is thrown upon very hot oil, or when a melted and red-hot metal is poured into a moiſt veſſel.

We ought to obſerve upon the ſubject of theſe exploſions, that they only happen when the volatile bodies are in an aggregate ſtate, or are combined with other volatile bodies; for the moſt volatile ſubſtances, when combined with fixed bodies, may be expoſed to the moſt violent heat without producing theſe effects. Thus water, when combined with quicklime, with fixed alkali, and other ſalts, may be ſuddenly expoſed to a red-heat without danger of exploſion.

Water ſeems to be unalterable and indeſtructible: at leaſt, no experiment is hitherto known, from which we may infer that water may be decompoſed. With whatever ſubſtances it may be combined, when ſeparated from theſe and ſufficiently purified, it is always found to be the ſame as before. When it is diſtilled ſingly, or mixed with ſome other ſubſtance, its nature and eſſential properties ſtill remain unchanged.

Some philoſophers, as Boyle, and eſpecially Mr. Margraaf, having very frequently diſtilled the ſame water, obtained at each operation a ſmall portion of earth; but the water which was diſtilled remained always eſſentially the ſame. The ſmall quantity of earth ſeparated from the water ought to be conſidered as extraneous to it. M. Lavoiſier has aſcertained this important fact by a ſeries of accurate experiments which are related in a Memoir preſented to the Academy of Sciences. He obtained at each diſtillation a ſmall quantity of earth; but he found that it came from the

Veſſels, as appeared upon examining the weight of theſe
fore and after the operations.

The famous experiment of Van Helmont, which
ſince his time been more carefully repeated by others,
which conſiſts in making trees and plants grow merel
means of water, does not prove, as ſome have ſuppoſed,
pure water is convertible into earth, ſalts, oil, and
other principles of vegetables; becauſe water not
contains a ſmall quantity of earth mixed with it, but
the air alone is the vehicle of a conſiderable quantit
theſe principles, or of ſuch as are capable of producing t

Water therefore appears to be a body ſimple and una
able: at leaſt chemiſts, not having any means of decom
ſing it, may conſider it as ſuch. They have accordi
claſſed it amongſt the *elements* or primary principles.
ELEMENTS *and* PRINCIPLES.

Many experiments and chemical analyſes ſhew,
water enters as a principle in the combination of many c
pound bodies, ſuch as all ſaline and oily ſubſtances (*See* S
*and* OIL); and conſequently that it is a part of all v
table and animal matters, and of all the ſaline part
minerals. Several ſtones even, in which no ſaline m
appears, as calcareous ſtones, contain a certain quanti
water, which ſeems to be in a ſtate of combination.
EARTH (CALCAREOUS) *and* QUICKLIME. But hith
no experiment ſhews, that water enters as a principle
the combination of *metallic matters*, or even into tha
*vitreſcible ſtones*. *See theſe words*.

Water diſſolves many bodies. It ſeems to be capab
diſſolving a certain quantity of *air*; for all natural w
being placed under an exhauſted receiver emits many
bubbles; and, according to Mr. Muſchenbroek, the w
from which air has been thus ſeparated, is capable o
ſuming the ſame quantity of air; that is to ſay, if a
quantity of air be introduced into this water, it will
form a bubble, as it would with water already ſatu
with air, but incorporates with the water, and entirely
appears. But this effect is much more ſenſible with m
kinds of gas, which have till lately been confounded
air. The gas which is expelled by the effervefcenc
acids and alkalis is one of thoſe with which water ch
itſelf in greateſt quantity. *See* WATERS (MINERAL)
GAS.

Water ſeems alſo capable of diſſolving a ſmall quanti
calcareous earth; for the moſt limpid, clear water b
diſti

distilled, always deposites some part of this earth. Some very limpid spring waters contain so much calcareous earth, that they deposit a sediment which encrusts any bodies that happen to be immersed in them. These waters become thus impregnated by flowing through large quantities of calcareous earth. Such are the waters of D'Arcueil near Paris, and all those which form incrustations, petrefactions, and stalactites. But it is probable that this small portion of calcareous earth is dissolved in the water merely by means of the gas contained in this liquid.

*Metallic matters*, excepting the perfect metals, are acted upon by water, but especially by the vapor of water, together with the concurrence of air. It converts their surfaces into rust.

But, of all known bodies, *saline substances* are most easily and copiously soluble in water. A strong affinity is observable between this element and all saline substances; so that we may say in general, that all salts are soluble in water; that every body truly soluble in water is of a saline nature; and that no other body can be dissolved in water but by means of a saline substance. *See* SALTS.

*Spirit of wine*, and all ardent spirits of the same kind, may be dissolved in water in all proportions. *See* SPIRIT (ARDENT).

The *spiritus rector* of vegetable and animal substances, and most of the very thin and very volatile fluids, called *gas*, are soluble in water. *See these words.*

*Ethereal liquors*, as vitriolic, nitrous, marine, and acetous *ethers*, are soluble in water, but only in certain proportions. *See* ETHER.

Water dissolves the most subtle and volatile part of any *oils*, as Mr. Beaumé has observed. *See* OILS.

Compounds, formed of any oily matters united with saline matters (to which compounds we ought to give the general name of *soap*, or *saponaceous substance*) are soluble in water, so much more easily and copiously as their saline principle is in greater quantity, and more disengaged or unfolded. *See* SOAP.

Lastly, water is the proper solvent of all *mucilaginous*, *gummy*, and *gelatinous matters*; which matters are composed of saline, oily, and earthy principles. *See* GUM.

We may easily perceive from what has been said concerning the properties of water, that it must be very useful in many chemical operations: but as it dissolves so many

 bodies,

bodies, and probably even all bodies, it can ſeldom be f
naturally free from heterogeneous matter, or perfectly
The waters of rivers and of ſprings, however limpid
may be, always contain a certain quantity of earth, w
is in the intermediate ſtate above-mentioned, betwe
ſimple interpoſition of parts, and a true ſolution, o
means of ſome gas. The beſt waters of this kind are
which flow through ſands, gritt-ſtone, and other vitri
matters; becauſe vitrifiable earth is leaſt capable of
attacked by water.

The waters of many ſprings and rivers contain mo
leſs of a gypſeous or ſelenitic ſubſtance really diſſolved
as water is capable of diſſolving theſe matters, and
flows through grounds containing them, it muſt diſſ
certain quantity of them, and even as much as ſatu
it. Waters impregnated with ſelenites are unfit for
mical operations, for being drank, for diſſolving ſoa
for boiling leguminous vegetables. They are a ki
*mineral waters*, and are called *crude* or *hard waters*.
*theſe words.*

Rain or ſnow waters, properly collected, that is, r
ſtormy weather, after it has already rained or ſnowed
time, in open air, and far from the habitations of men
received in earthen-ware veſſels, are the beſt and the
of all native waters. They are ſufficiently pure for
chemical operations, becauſe they have been purified
kind of natural diſtillation: but for greater exactneſs
becauſe theſe waters are not always procurable, di
water is generally employed in chemical operations
WATER (DISTILLED). *(g)*

WA

*(g)* Native water is ſeldom, if ever, found perfectly
The *waters* that *flow within*, or *upon the ſurface of the*
contain various earthy, ſaline, metallic, vegetable or anim
ticles, according to the ſubſtances over or through whic
paſs. *Rain* and *ſnow waters* are much purer than thoſe,
they alſo contain whatever floats in the air, or has been e
along with the watery vapors. Mr. Margraaf has very acc
analyſed, by gentle diſtillation, ſome clear rain and ſnow
that he had very carefully collected in glaſs veſſels. The
reſiduums obtained by diſtilling a hundred meaſures of rain-
each of which contained thirty-ſix ounces, he diſtilled an
porated, till no more remained than ſix or eight ounces of
which was very turbid. From this remainder he obtain
filt

WATERS (AROMATIC). Thoſe are called aromatic waters that are impregnated by diſtillation with the

filtration, a hundred grains of a yellowiſh-white calcareous earth; and the filtrated liquor ſtill contained ſome earthy particles ſuſpended in it. Upon adding ſome drops of a ſolution of ſalt of tartar to this filtrated liquor, he obtained by evaporation a few grains of cryſtals, which had the appearance of nitre and common ſalt. From theſe cryſtals he inferred, that the rain-water contained a ſmall portion of nitrous and marine acids; and from the color of the cryſtals, which was browniſh, he concludes that it alſo contained ſome oil and viſcous particles. He further proved the preſence of marine acid in rain-water by adding a concentrated reſiduum of diſtilled rain to ſolutions of ſilver, mercury, and lead in nitrous acid; from all which ſolutions, precipitates were thereby formed. He diſcovered the earthy, ſaline, mucilaginous and oily principles by expoſing rain-water to the rays of the ſun, during ſome months in a glaſs-veſſel; covered ſo as to exclude the duſt, but not air; by which means, the water underwent a kind of fermentation or putrefaction, and a greeniſh ſlime was formed on the ſides and bottom of the containing veſſel. This fermentation, he found, could not be excited, by treating in the ſame manner the rain-water that had paſſed over in the diſtillation made in order to procure the above-mentioned reſiduums.

M. Margraaf having treated a hundred meaſures of *ſnow-water* in the ſame manner as he had done the rain-water, obtained ſixty grains of a ſimilar white calcareous earth, together with the ſame ſaline, mucilaginous and oily principles, but obſerved that the rain-water contained a larger proportion of the nitrous acid, and the ſnow-water more of the marine acid. Upon a further examination of the calcareous earths obtained from rain and ſnow, he diſcovered that they contained a ferruginous matter.

The *purity of water* may be known by the following marks or properties of pure water.

1. Pure water is lighter than water that is not pure; for not only the ſubſtances uſually diſſolved in water, are heavier than water, but alſo the ſpecific gravity of a ſolution of any of theſe ſubſtances in water, is generally greater than the intermediate ſpecific gravity of the water and of that ſubſtance.

2. Pure water is more fluid than water that is not pure: hence it is ſaid to occaſion a louder ſound when poured from one veſſel into another.

3. It has no color, ſmell, or taſte.

4. It wets more eaſily than the waters containing metallic and earthy ſalts, called *hard waters*, and feels ſofter when touched.

the ſpiritus rector, or odoriferous principle of aroma
matters. *See* WATERS (DISTILLED).



5. Soap, or a ſolution of ſoap in ſpirit of wine, mixes ea
and perfectly with it.

6. It is not rendered turbid by adding to it a ſolution of g
in aqua regia, or a ſolution of ſilver, or of lead, or of merc
in nitrous acid, or a ſolution of ſugar of lead in water.

Boerhaave, the author of this Dictionary, and other chem
maintain, that pure water is unalterable; and others, as B
chius, Boyle, Wallerius, that it may be decompoſed or reſol
into other principles, eſpecially into earth.

Boyle relates, that one ounce of water, diſtilled carefull
glaſs-veſſels two hundred times, yielded ſix drams of a wh
light, inſipid earth, fixed in the fire, and indiſſoluble in wa
Boerhaave attributed the earth obtained by diſtillation of wate
duſt floating in laboratories. Other chemiſts have made exp
ments to aſcertain the truth of that of Mr. Boyle. Lieden
found, that when pure diſtilled water is diſſipated or evapor
by throwing it into a red-hot iron ſpoon, he always obta
a quantity of earth. Wallerius obtained a ſcruple and a hal
fine white earth by triturating during two hours a dran
diſtilled water. This earth, he ſays, is ſoluble in acids
convertible into a hard maſs by a red-heat, which maſ
unſoluble by acids, and is vitrifiable into a white tranſpa
glaſs by a more violent heat. He found alſo, that a la
quantity of earth is depoſited from boiling water with a ſtr
than with a gentle fire. *See the Swediſh Memoirs for the*
1760. Mr. Margraaf has made experiments with his accuſto
accuracy, from which it appears, that by diſtillation, and
by evaporation with the heat of the ſun, of rain water,
purity of which had been previouſly aſcertained by thir
diſtillations, he obtained a white, light, ſhining earth.
earth could not be vitrified with the heat requiſite for the fu
of ordinary glaſs; but by a more violent and longer conti
fire it was melted into a yellow-greyiſh maſs. He found,
about half of this earth was ſoluble in nitrous acid, and tha
other half was not fuſible by fire; but that, by additio
half its quantity of ſalt of tartar, it was convertible into a t
parent glaſs. The part of the earth that was diſſolved in ni
acid was afterwards precipitated from that acid by vitriolic
with which it formed a ſelenites; and hence Mr. Margraaf in
that it is a true calcareous earth. He does not determine
claſs of earths to which the unſoluble part of the earth thu
tained by diſtilling water ought to be referred. Mr. Mar
obſerves, that earth is more copiouſly depoſited from
boiling with a ſtrong than with a gentle heat. The quanti

TER (DISTILLED). Moſt natural waters ſome heterogeneous ſubſtances that render them impure;

t he obtained, in one experiment, from ſeventy-two f diſtilled water, by twelve diſtillations, was nine or ten

voiſier however maintains, as is mentioned in the text, earth thus obtained by diſtilling water proceeds from the nployed.

ırgraaf proved the exiſtence of earth in water by another nt. He put two ounces of diſtilled water into a glaſs inches high, and from one to two inches in diameter, d the mouth with a ſmooth glaſs ſtopper. After the l been agitated up and down in this tube eight days, it rved to be turbid, and upon continuing the agitation ys longer, he obſerved diſtinctly, eſpecially upon exe tube to the rays of the ſun, particles of earth floating ter.

is article we ſhall ſubjoin three Tables of different ſhewing what quantity of each ſalt is ſoluble in a given of water; and alſo an account of ſome experiments made ller, to ſhew how much of certain ſalts may be diſſolved quantities of water ſaturated previouſly with other ſalts.

ollowing Table ſhews the quantities of the ſaline ſubat could be diſſolved in an ounce of water, with the heat Fahrenheit's ſcale, according to experiments made by man. *Inſtit. Chemiæ*, p. 48.

| | Grains |
|---|---|
| iata tartari | 470 |
| dlitz | 384 |
| lt | 324 |
| rtar | 240 |
| e ſalt | 212 |
| riol | 210 |
| | 200 |
| da | 200 |
| oniac | 176 |
| ſalt | 170 |
| lauber | 168 |
| orraine | 168 |
| ylvius | 160 |
| eignette | 137 |
| iol | 124 |
| riol | 80 |
| itre | 60 |
| chreſt of Glaſer | 40 |
| ed tartar | 30 |

pure; and as water exceedingly pure is required for
chemical operations, it must be therefore purified for
pur

| | |
|---|---|
| Sublimate mercury | — |
| Borax | — |
| Alum | — |
| Volatile salt of amber | — |
| Arsenic | — |
| Crude tartar | — |
| Cream of tartar | — |

The following Table is copied from Mr. Muschenbroek.
eight first experiments were made by Boerhaave, and the
Muschenbroek, with a heat of 38°.

| | | | | |
|---|---|---|---|---|
| Sea-salt, | oz. 2. | were dissolved in | oz. 6. and dr. 3. | of pure wa |
| Sal gem, | oz. 1. | — | oz. 3. and dr. 2. | — |
| Sal ammoniac, | oz. 1. | — | oz. 3. and dr. 2. | — |
| Nitre, | dr. 9. | — | oz. 6. | — |
| Borax, | dr. 4. | — | oz. 10. | — |
| Alum, | oz. 1. | — | oz. 14. | — |
| Epsom salt, | oz. 1. | — | oz. 1. and dr. 2. | — |
| Green vitriol, | dr. 1. ½ | — | oz. 3. | — |
| Arsenic, | oz. 1. | — | oz. 30. | — |
| Blue vitriol, | gr. 50. | — | gr. 850. | — |
| Salt of harthorn, | gr. 50. | — | gr. 765. | — |
| Sugar of lead, | gr. 50. | — | gr. 595. | — |
| Salt of tartar, | gr. 50. | — | gr. 85. | — |
| Glass-gall, | gr. 50. | — | oz. 7 ¼. | — |
| Cream of tartar, | gr. 50. | — | gr. 1000. | of boiling w |

[Fifty grains of cream of tartar may be dissolved in 100
of lime-water. *Hist. de l'Acad. Royale.* 1732.]

Sugar of milk, dr. 7. were dissolved in lb. 1. of water
to the 167°.

According to Neuman's experiments, the quantities o
soluble in an ounce of water are expressed in the following
He does not mention the heat employed.

| | |
|---|---|
| White powdered sugar, | oz. 2. |
| Brown powdered sugar, | oz. 2. |
| White or brown sugar candy, | dr. 9. |
| Sal diureticus, | oz. 1. |
| [illegible]som salt, | oz. 1. |
| [illegible]litz salt, | dr. 6. |
| Pure fixed alkali, | dr. 6. |
| [illegible] vitriol, | oz. ½. |
| [illegible] vitriol, | oz. ½. |
| [illegible], | dr. 3. |
| [illegible]it, | dr. 3. |
| Salt of Glauber, | dr. 2. |

purposes by distillation. Water may be distilled in the following manner:

The

| | |
|---|---|
| Sal ammoniac, | dr. 2. |
| Volatile sal ammoniac, | dr. 2. |
| Potash, | dr. 2. |
| Blue vitriol, | dr. 2. |
| Pure nitre, | dr. 1. gr. 10. |
| Sal prunell, | dr. 1. |
| Soluble tartar, | dr. 1. |
| Alum, | scr. 2½ |
| Sal polychrest, | scr. 2. |
| Arcanum duplicatum, | dr. ½ |
| Vitriolated tartar, | dr. ½. |
| Sugar of milk, | scr. 1. |
| Sugar of lead, | scr. 1. |
| Emetic tartar, | scr. 1. |
| Borax, | gr. 15. |
| Salt of sorrel, | gr. 10. |
| White tartar, | gr. 5. |
| Crystals of tartar, | gr. 5. |

Water, when saturated with one salt, is capable of dissolving a considerable portion of another salt; and when saturated with this also, it may still dissolve a third, a fourth, or more salts. Thus, according to Neuman, four ounces of water, that have been saturated with a dram and a few grains of alum, will still dissolve five drams of nitre, then half an ounce of green vitriol, six drams of common salt, three drams of soluble tartar, and five drams of sugar. In the same manner also, four ounces of water saturated with half an ounce of nitre, will dissolve half an ounce of white vitriol, six drams of common salt, six drams of sal ammoniac, half an ounce of soluble tartar, and after all these, an entire ounce of sugar.

Mr. Eller has published an account of the following experiments concerning the solutions of different salts in the same water. *See Mem. of the Acad. of Berlin for the year* 1750.

In each experiment he employed *eight ounces of distilled water*. He found that this quantity of water, when saturated

*With four ounces of nitre*, dissolved one ounce, five drams of fixed alkali, and half an ounce of common salt:

*With three ounces, one dram, and one scruple of common salt*, dissolved three drams of nitre, and five drams of fixed alkali:

*With three ounces and a half of fossil salt*, dissolved half an ounce of nitre:

*With half an ounce of cream of tartar*, dissolved half an ounce of Sedlitz salt, and half an ounce of fixed alkali:

*With*

The pureſt natural water that can be procured, as water of rain or of ſnow, or of ſprings and rivers that over ſands, and are very limpid, is to be put into a w tinned copper alembic, which muſt be very clean, or wl is only employed for this purpoſe, and the diſtillation i be promoted with a gentle fire.

The firſt portion of water that paſſes into the rece ought to be thrown away, becauſe it waſhes the alen and receiver, and becauſe if the water contained accident any volatile heterogeneous matters, theſe will riſe with firſt portion of diſtilled water.

The diſtillation is to be diſcontinued, when two-third water have nearly paſſed, becauſe what remains in the alem is loaded with a larger proportion of heterogeneous ſtances, ſome of which the water might raiſe along wit in diſtillation. *See* DISTILLATION.

Diſtilled water ought to be put into very clean bot and ſtopped with glaſs ſtopples.

Water is known to have been ſufficiently purified diſtillation, when it does not change the color of the t tures of violets, or of turnſol, and when its limpidity is

*With an ounce and a half of vitriolated tartar*, diſſolved hal ounce of fixed alkali:

*With three ounces and a half of Glauber's ſalt*, diſſolved drams of nitre, and as much ſugar.

*With four ounces of ſoluble tartar*, diſſolved half an ounc pure nitre.

*With four ounces of Epſom ſalt*, diſſolved half an ounce of ſugar.

*With two ounces and a half of ſal ammoniac*, diſſolved five dr of foſſil ſalt.

*With an ounce and a half of volatile ſalt of hartſhorn*, diſſo an ounce of nitre and half an ounce of ſugar.

*With four drams and two ſcruples of borax*, diſſolved hal ounce of fixed alkali.

*With two ounces and a half of alum*, diſſolved ſix drams of c mon ſalt, and one dram of Epſom ſalt:

*With nine ounces and a half of green vitriol*, diſſolved an ou and a half of Sedlitz ſalt, two drams of nitre, and three ounce refined ſugar:

*With nine ounces of blue vitriol*, diſſolved an ounce of nitre, t drams of common ſalt, and an ounce of ſugar:

*With four ounces and a half of white vitriol*, diſſolved ounce of refined ſugar.

hurt by adding to it ſolutions of mercury or of ſilver in nitrous acid.

WATERS (DISTILLED). The *diſtilled waters of plants*, or of *other matters*, are prepared by diſtilling water from theſe ſubſtances, and are thus impregnated with ſuch principles as may be raiſed by diſtillation, with the heat of boiling water.

If the plants thus expoſed to diſtillation with water, manifeſtly contain volatile principles, as all thoſe do which have a diſtinguiſhing ſmell, we cannot doubt that their diſtilled water muſt be impregnated with their odoriferous principle, or of ſpiritus rector. Theſe waters are called *aromatic waters*. *See* SPIRITUS RECTOR.

The water that is uſed in the diſtillation of all eſſential oils is found much impregnated with the odoriferous principles of the aromatic plants employed; and conſequently it is a good diſtilled water of theſe plants.

An opinion ſeems to have formerly prevailed, that even the plants called *inodorous*, might impregnate water with ſome of their principles by diſtillation; for ſuch diſtilled waters are preſcribed in many diſpenſatories. But lately, theſe diſtilled waters have been neglected, and are even conſidered only as common water. This latter kind of diſtilled water is ſenſibly leſs impregnated with principles than the former. But are we certain that they contain nothing of the principles of the plant? Are thoſe plants, whoſe ſmell is not very perceptible, entirely deſtitute of all odoriferous principle? Could not a perſon whoſe ſenſe of ſmell was very acute and much exerciſed, diſtinguiſh plantain and other herbs commonly called inodorous, from each other by ſmell, eſpecially if they were previouſly cut and bruiſed?

We may alſo obſerve, that the manner commonly employed for diſtilling ſuch waters is not well adapted to procure all the peculiar ſmell and qualities of the plants employed. The plants are generally put into an alembic, and overwhelmed with a large quantity of common water. The diſtillation is then promoted; the water is made to boil quickly; and the veſſels are ſeldom even luted. What can be expected from this bad management, but that the ſpiritus rector of theſe plants that is in very ſmall quantity, and perhaps exceedingly volatile and fugacious, ſhould be entirely diſſipated? or if any of it remains in the water, that it ſhould be diſguiſed and covered by the empyreumatic ſmell that all theſe waters have when newly diſtilled, or by the

ſmell

ſmell which they acquire by time, ſo that they canno
diſtinguiſhed from each other?

But if we follow exactly the excellent method directe
the Paris Diſpenſatory; or if we improve upon this by put
the herbs recent, cut, and bruiſed, into an alembic pl
in a water-bath, without adding water to them, and
diſtilling to dryneſs, with a very gentle heat and well l
veſſels; and if we then find that the ſmall quantity of w
thus diſtilled from plants, called inodorous, has no ſmell
taſte, and gives all the chemical proofs of pure water,
may then juſtly conſider theſe waters as deſtitute of an
the principles and virtues of the plants employed.

Waters called ſimply *diſtilled waters*, are underſtood t
thoſe that are prepared with common water. But as ſp
of wine is alſo frequently impregnated with the odorife
principle of plants and other ſubſtances by diſtillation,
as theſe alſo have been called *waters*, they ought to be di
guiſhed by the name, *aromatic ſpirituous waters*. Such
the *ſpirituous water of Lavender*, the *ſpirituous water of th*
&c. Theſe ſpirituous waters are alſo ſometimes ca
*ſpirits*, as *ſpirit of thyme*, *ſpirit of citrons*, &c.

Aromatic ſpirituous waters are impregnated with
ſmell of one ſubſtance only, or of ſeveral ſubſtances.
former are called *ſimple*, and the latter *compound*.

Many of theſe waters are prepared for the uſes of m
cine, of the toilette, and of the table. The preparatio
theſe waters requires only the uſual attentions to be g
to all diſtillations. Whatever relates to this ſubject
be found in *Mr. Beaumé's Elements of Pharmacy*. We
there ſee that the ſtrength and agreeable flavor of theſe wa
chiefly depend on the ſtrength of the ſpirit of wine emplo
and eſpecially on its purity from any oil of wine, w
gives the diſagreeable ſmell and taſte of common aqua-
*See* SPIRIT (ARDENT).

WATERS (HARD *or* CRUDE). Theſe na
are applied to all waters that contain any ſenſible quanti
earth or ſelenites. *See* WATERS (MINERAL). *(g)*

WAT

*(g) Hard waters* are thoſe in which ſoap does not diſſolve
formly, but is curdled. The diſſolving power of hard wa
leſs than that of *ſoft*; and hence its unfitneſs for bleaching,
ing, boiling leguminous vegetables, and for many other pur
of economy and arts. One cauſe of the hardneſs of water is,
it contains ſome ſalt that may be decompoſed by ſoap, the a

WATER (LIME). Lime water is ordinary water in which quicklime has been ſlaked.

Water in which quicklime has been ſlaked, or with which ſlaked quicklime is waſhed, diſſolves the part of the quicklime that is moſt attenuated, and moſt deprived of gas: this ſubſtance, which may be conſidered as ſaline and earthy, communicates to water an alkaline, and ſomewhat acrid taſte. The effects of lime water in chemical mixtures are ſimilar to thoſe produced by quicklime. *See* QUICKLIME.

Although lime-water contains no volatile principle, it ought nevertheleſs to be preſerved in full and well cloſed

of which uniting with the acid of the ſalt, the oil of the ſoap ſeparates, and the ſoap is ſaid to be curdled. Hardneſs of water proceeding from this cauſe may be diſcovered and cured by adding ſome drops of a ſolution of fixed alkali. The ſalts capable of rendering water hard, are not only ſelenites, which is a very frequent cauſe of the hardneſs of water, but any other earthy or metallic ſalt that may be contained in the water, as all theſe are capable of being decompoſed by fixed alkali. Such are the marine ſalt with baſis of magneſia, or of calcareous earth, vitriolic ſalt with baſis of magneſia called Epſom ſalt, green vitriol, and a nitrous ſalt with earthy baſis, to which Dr. Home attributes the hardneſs of ſeveral waters examined by him. The hardneſs of water has been by ſome perſons attributed to common ſalt. But Dr. Home in his *Eſſay on Bleaching* has ſhewn, that neither pure common ſalt, nor any other ſalt with baſis of fixed alkali, give any hardneſs to water, but that this quality may be given to water by the common ſalt which is generally ſold, becauſe this contains ſome part of the earthy ſalts of ſea-water, or of the water of ſalt-ſprings.

The gas which waters frequently contain, is another cauſe of the hardneſs of water. This gas unites with the alkali of ſoap, renders it mild, and thus weakens its union with the oil. *See* GAS *and* ALKALI (FIXED). This gas, by expoſure of the water during ſome time in open veſſels, exhales; by which means, water is rendered ſoft, and any calcareous earth or iron which may be diſſolved in the water merely by means of the gas, as Mr. Cavendiſh and Mr. Lane have ſhewn, [*Philoſ. Tranſ.* 1767 & 1769.] are precipitated.

By boiling, the hardneſs of water proceeding from gas may be cured, but that from earthy or metallic ſalts cannot.

Spring-waters are frequently hard. River water is generally ſoft. The ſmall quantity of earthy ſalts contained in rain and ſnow waters, according to Mr. Margraaf's analyſis, does not ſenſibly render them hard.

bottles:

bottles: otherwiſe the ſaline earthy matter diſſolved in
to which it owes all its peculiar properties, would be ſep
rated from it, in proportion as the water ſhould be evap
rated, and would appear on the ſurface in form of a cru
called *cream of lime*. The quantity of calcareous mat
that is thus ſeparated from lime-water, is even greater th
it ought to be, if it was exactly proportionate to the evap
ration of the water. The cauſe of which is, that the quic
lime gradually recovers from the air as much gas as
neceſſary to deprive it of its properties of quicklime, and
reſtore it to its ſtate of ſimple calcareous earth, mild, eff
veſcing, and unſoluble in water. Hence lime-water,
long expoſure to air, loſes much of its ſtrength, and at l
becomes almoſt inſipid. *See a note ſubjoined to the arti*
QUICKLIME.

WATER (MERCURIAL). This name is giv
to a ſolution of mercury in nitrous acid, diluted with
greater or leſs quantity of common water.

This liquor produces very good effects, as an eſcharot
and even as a cauſtic in ſome diſeaſes of the ſkin that a
external, local, and eſpecially venereal. Some perſons u
this mercurial water internally; but as it muſt be a dange
ous remedy, it ought not to be employed.

WATERS (MINERAL). All waters natura
impregnated with any heterogeneous matter which they ha
diſſolved within the earth may be called *mineral waters*,
the moſt general and extenſive meaning of that name:
which are therefore comprehended almoſt all thoſe that flo
within, or upon the ſurface of the earth: for almoſt
theſe contain ſome earth or ſelenites. But waters contai
ing only earth or ſelenites are not generally called *miner*
but *hard* or *crude waters*.

The hard waters, which are ſimply ſelenitic, when tri
by the chemical proofs hereafter to be mentioned for d
covering the nature of mineral waters, ſhew no marks of
acid or of an alkali, nor of any volatile, ſulphureous,
metallic matters. Waters which contain a diſengaged ca
careous earth, change the color of ſyrup of violets to a gree
and thoſe that contain ſelenites, being mixed with a ſoluti
of mercury in nitrous acids form a turbith mineral; a
when a fixed alkali is added, they are rendered turbid, and
white ſediment is precipitated. Theſe waters alſo do n
diſſolve ſoap well. From theſe we may know, that a
water which produces theſe effects is a hard, earthy, or ſel
nitic water. The waters impregnated with gas are alſo har

Althou

Although the waters of the ſea, and ſaline ſprings, be not generally enumerated amongſt mineral waters, they might nevertheleſs be juſtly conſidered as ſuch. For beſides earthy and ſelenitic matters, they alſo contain a large quantity of mineral ſalts. We ſhall therefore conſider them as ſuch in this article.

Mineral waters, properly ſo called, are thoſe in which gas, or ſulphureous, ſaline or metallic ſubſtances are diſcovered by chemical trials. As many of theſe waters are employed ſucceſsfully in Medicine, they are alſo called *medicinal waters*.

Mineral waters receive their peculiar principles by paſſing through earths containing ſalts, or pyritous ſubſtances that are in a ſtate of decompoſition. *See* PYRITES.

Some of theſe waters are valuable from the quantity of uſeful ſalts which they contain, particularly of common ſalt, great quantities of which are obtained from theſe waters; and others are chiefly valued for their medicinal qualities.

The former kind of mineral waters is an object of manufacture, and from them is chiefly extracted that ſalt only which is moſt valuable in commerce. *See* WATER *of the* SEA; *and* WATER *of* SALINE SPRINGS.

But the nature and proportion of all the principles of which medicinal waters conſiſt, ought to be carefully examined. Many of theſe waters have been accurately analyſed by able chemiſts and phyſicians.

But notwithſtanding theſe attempts, we are far from having all the certainty and knowledge that might be deſired on this important ſubject; for this kind of analyſis is perhaps the moſt difficult of any in chemiſtry.

Almoſt all mineral waters contain ſeveral different ſubſtances, which being united with water may form with each other numberleſs compounds. Frequently ſome of the principles of mineral waters are in ſo ſmall quantity, that they can ſcarcely be perceived; although they may have ſome influence on the virtues of the water, and alſo on the other principles contained in the water.

The chemical operations uſed in the analyſis of mineral waters, may ſometimes occaſion eſſential changes in the ſubſtances that are to be diſcovered. And alſo, theſe waters are capable of ſuffering very conſiderable changes by motion, by reſt, and by expoſure to air.

Probably alſo the variations of the atmoſphere, ſubterranean changes, ſome ſecret junction of a new ſpring of mineral

mineral or of pure water; laſtly, the exhauſtion of minerals whence waters receive their peculiar princi are cauſes which may occaſionally change the quali mineral waters.

We need not therefore wonder, that the reſults of ana of the ſame mineral waters made by different chem whoſe ſkill and accuracy are not queſtioned, ſhould be different.

The conſequences of what we have ſaid on this ſul are, that the examination of mineral waters is a very diff taſk; that it ought not to be attempted but by profe and experienced chemiſts; that it requires frequent re tions, and at different times; and laſtly, that no f general rules can be given concerning theſe analyſes.

As this matter cannot be thoroughly explained wit entering into details connected with all the parts of chemi we ſhall here mention only the principal reſults, and moſt eſſential rules that have been indicated by the atte hitherto made on this ſubject.

We may admit the diviſion or arrangement of mi waters into certain claſſes, propoſed by ſome of the beſt miſts and naturaliſts.

Some of theſe waters are called *cold*, becauſe they are naturally hotter than the atmoſphere. Some of them even colder, eſpecially in ſummer.

Thoſe are called *hot mineral waters*, which in all ſea are hotter than the air. Theſe are of various degrees of h and ſome of them are almoſt as hot as boiling water. ſome mineral waters certain volatile ſpirituous and el principles may be perceived, by a very ſenſible piq taſte; this principle is called the *gas*, or the *ſpiri waters*.

The waters which contain this principle are gene lighter than pure water. They ſparkle and emit bub at their ſpring, but eſpecially when they are ſhook, poured from one veſſel into another. They ſometimes b the bottles containing them, when theſe are well corke fermenting wines ſometimes do. When mixed with ordi wine, they give to it the piquancy and ſparkling quali Champaigne wine.

This volatile principle, and all the properties of the w dependant upon it, are loſt merely by expoſure to air o agitation. The waters containing this principle are di guiſhed by the name of *ſpirituous mineral waters*, or *ac lous waters*.

C

Other divisions of mineral waters may be made, relatively to some of their predominant principles. Hence some waters are called *acidulous*, *alkaline*, *martial*, *neutral*, &c.

When a mineral water is to be examined, we may observe the following rules:

Experiments ought to be made near the spring, if possible.

The situation of the spring, the nature of the soil, and the neighbouring rising grounds ought to be examined.

Its sensible qualities, as its smell, taste, color, are to be observed.

Its specific gravity and heat are to be ascertained by the hydrostatical balance and the thermometer.

From the properties above-mentioned of spirituous mineral waters, we may discover whether it be one of this class. For greater certainty we may make the following trial. Let the neck of a wet bladder be tied to the neck of a bottle containing some of this water. By shaking the water, any *gas* that it may contain will be disengaged, and will swell the bladder. If the neck of the bladder be then tyed with a string above the bottle, and be cut below this string, so as to separate the bladder from the bottle, the quantity and nature of the contained *gas* may be further examined.

Lastly, we must observe the changes that are spontaneously produced upon the water in close and in open vessels, and with different degrees of heat. If by these means any matter be crystallized or deposited, it must be set apart for further examination.

These preliminary experiments and observations will almost certainly indicate, more or less sensibly, something concerning the nature of the water, and will point out the method to be followed in our further inquiry.

We must then proceed to the decomposition of the water either without addition and merely by evaporation and distillation, or with the addition of other substances, by means of which the matters contained in the water may be precipitated, and discovered. It is not material which of these two methods be first practised, but it is quite necessary that the one should succeed the other. If we begin by evaporating and distilling, these operations must be sometimes interrupted, that the several principles which rise at different times of the distillation may be obtained and examined separately, and also to allow the several salts that may be contained, to crystallize by the evaporation and by

cold. *See* EVAPORATION, DISTILLATION, *and* CRY: LIZATION.

The ſubſtances generally found in mineral wate almoſt always combinations of vitriolic acid, and th marine acid, together with the ſeveral matters that acids are capable of diſſolving.

The following combinations of vitriolic acid are fo mineral waters.

1. *Volatile ſulphureous acid.* This is ſeldom found. becauſe it eaſily loſes its phlogiſton, and becauſe it almoſt always meet with ſome ſubſtance that it is capa diſſolving.

2. *Sulphur.* This is found ſometimes ſingly, but rally in form of a liver of ſulphur. In theſe waters, ſu is formed into a hepar by means of calcareous earth or neral alkali.

3. *Vitriolic ſalts with earthy baſes.* Theſe ſalts af quently *ſelenitic*, that is, their acid is combined w calcareous earth; or, they are of the nature of Epſon the baſis of which is magneſia. Sometimes, but frequently, they are *aluminous*, when their acid happe be united with an argillaceous earth.

4. *Vitriols. Martial vitriol* is frequently contain mineral waters; *vitriol of copper* is ſometimes, but ſe and *vitriol of zinc* is ſtill more rarely found in theſe w The vitriols of other metallic ſubſtances are ſcarcely but in very ſingular caſes, found in water.

5. Laſtly, *vitriolic ſalts with baſis of fixed alkali.* T always *Glauber's ſalt.* Neither *vitriolated tartar* nor *v ammoniacal ſalt* are ever found, unleſs by ſome ſingul cident, in mineral waters.

The combinations of marine acid that are contai mineral waters are *common ſalt*, and *marine ſalt with baſis.* For no combinations of this acid with phlogiſt known, and it is very ſeldom found united with any m ſubſtance.

Compounds formed of the nitrous acids are, in a ma ſubſtances extraneous to the mineral kingdom, ſinc acid is never produced but upon the ſurface of the and from vegetable and animal matters. *See* ACID TROUS) *and* NITRE. This acid cannot therefore be in waters but very accidentally. Thus, for inſtance, is found in the wells of Paris, and probably of other t becauſe the ground where men inhabit is always nitro

These are the principal substances that form almost all these waters. We shall now shew the proofs by means of which they may be discovered in water, without decomposing the water by evaporation or by distillation.

If any portion of disengaged acid or alkali be contained in water, it may be known by the taste, by changing the color of violets or of turnsol, and by adding the precise quantity of acid or of alkali that is necessary for the saturation of the contained disengaged saline matter.

Sulphur, and liver of sulphur, may be discovered in waters by their singular smell, by the black color which these substances give to white metals or to their precipitates, but especially to silver.

Vitriolic salts with earthy basis may be discovered in water by two proofs: 1. By adding some fixed alkali, which decomposes all these salts, and precipitates their earthy basis; and, 2. By adding a solution of mercury in nitrous acid, which also decomposes these salts, and forms a *turbith mineral* with their acid. But for this purpose, the solution of mercury ought to have a superabundant quantity of acid: for this solution, when perfectly saturated, forms a precipitate with any kind of water, as M. Rouelle has very justly remarked; and indeed, all metallic solutions in any acids are strictly capable of decomposition by water alone, and so much more easily as the acid is more perfectly saturated with the metal.

Martial vitriol or iron combined with any acid, or even with gas, shews itself in waters by blackening an infusion of galls, or by forming a Prussian blue with the phlogisticated alkaline lixivium.

The vitriol of copper, or copper dissolved by any acid, may be discovered by adding some of the volatile spirit of sal ammoniac, which produces a fine blue color, or by the addition of clean iron, upon the surface of which the copper is precipitated in its natural or metallic state.

Glauber's salt is discovered by adding a solution of mercury in nitrous acid, and forming with it a turbith mineral; or by crystallization.

Common salt contained in waters forms with a solution of silver in nitrous acid a white precipitate, or luna cornea. It may also be known by its crystallization. Marine salt with earthy basis produces the same effect upon solution of silver. It also forms a precipitate when fixed alkali is added. The acrimony, bitterness, and deliquescency of this salt serve to distinguish it.

The proofs related for the examination of mineral wa
are only those which are most essential. Many others
be made to confirm the former proofs: but the detail
these are too extensive to be inserted here. We shall
only two of these, because they are very general, and
be very useful.

The first is the production of artificial sulphur, or of
volatile sulphureous acid; by which means the vitri
acid may be discovered in any combination whatever.
this purpose the matter to be examined must be mixed
any inflammable substance, and exposed to a red-heat.
this matter contained but a particle of vitriolic aci
would be rendered sensible by the sulphur, or by the
tile sulphureous acid thence produced. *See* SULPHUR.

The second general proof for mineral waters which
shall mention here serves to discover any metallic subst
whatever, dissolved in water by any acid. This proof
sists in adding some of the liquor saturated by the colo
matter of Prussian blue, discovered and described by
Macquer in his Memoir upon Prussian Blue. This li
produces no effects upon any neutral salts with earth
alkaline bases, but decomposes all metallic salts: so
if no precipitate be formed upon adding some of this li
we may be certain that the water does not contain any
tallic salt; and on the contrary, if a precipitate is for
we may certainly infer that the water does contain
metallic salt.

We may easily perceive the necessity of using no v
in these experiments, but such as are perfectly clear
rinsed with distilled water; of weighing the products o
experiments very exactly; of making the experiments
as large quantities of water as is possible, especially
evaporations, crystallizations, and distillations; an
repeating all experiments several times. We may fu
observe, that the mixtures from which any precip
might be expected, ought to be kept two or three
because many of these precipitates require that tim
more to appear, or to be entirely deposited.

We shall now endeavour to explain how mineral w
become impregnated with their principles.

The *selenitic* parts of water are received by this
while it flows through gypseous earth and stones,
being composed of selenites, which is soluble in water

The mines of sal gem which are in many places
particularly where salt-springs are, furnish the waters

flow through them, and perhaps the sea itself, with the *common salt* that they contain.

When a water once contains common salt, it may become impregnated with *Glauber's salt* by passing through clay; the vitriolic acid that is always contained in argillaceous earths, decomposing a part of the common salt of the water, with the basis of which it forms the Glauber's salt; while the marine acid now disengaged will unite with the first calcareous particles that it meets, and form a *marine salt with earthy basis*, which is accordingly always found in sea-water, and in salt-springs.

When water impregnated, or not, with saline principles flows through parts of the earth containing pyrites in a state of decomposition, it becomes impregnated with *sulphur*, with *martial vitriol*, with *vitriol of copper*, with *alum*, and with *other salts*; and frequently with several of these substances at the same time, according to the nature of the pyrites. *See* PYRITES.

The *heat of hot mineral waters* can be only acquired by washing large masses of pyrites and other similar minerals in a state of spontaneous decomposition, during which they always acquire considerable heat.

Lastly, the aerial *gas* of some mineral waters may have been discharged from some of the principles with which the water is impregnated, which were in the act of combination with each other at the time they were dissolved by the water, or which were combined after this solution. For we know that in almost all solutions much air is extricated; and this air being well divided and diffused among the particles of water, adheres to them, and in some measure combines with them superabundantly. Mr. Venel has made upon this subject a fine experiment, that proves the truth of the above-mentioned theory, which was first given by him. He added to common water as much marine acid and mineral alkali as were sufficient to form as much common salt as is contained in the mineral water of Selters. He corked very well the bottle containing this impregnated water. The combination proceeded slowly and without effervescence, because the saline matters were much diluted; and when the combination was completed, the artificial water was become spirituous and aerial, like the natural water that he imitated. *See the particular articles of all the substances mentioned that relate to mineral waters; from a knowledge of the properties of which substances,*

 *many*

*many explanations on this ſubject may be deduced, too long here inſerted.* (*b*)

WATERS (MOTHER). This name is given to liquor that remains after as much of the ſaline ſubſta contained in a water has been ſeparated as can be by the uſual methods, evaporation and cooling, and which therefore no more cryſtals can be obtained, w out much difficulty, though it ſtill remains impregn with ſalts. Theſe mother-waters are very different, cording to the kinds of ſalts with which the waters originally impregnated. They are generally very he acrid, and red.

The nature of mother-waters was a long time very perfectly underſtood. They were conſidered as liq lo

(*b*) The *gas* which gives the ſparkling and inebriating lities to many mineral waters, ſeems not to differ from the extricated from effervefcing and fermenting ſubſtances. Gas. The Honourable Mr. Cavendiſh has added to his fo important diſcoveries concerning different kinds of gas, one throws much light on the nature of many mineral waters. diſcovery is, that by means of gas, and without the interve of any acid, calcareous earth is diſſolved in ſome minera ters. He found that the quantity of this gas that was cont in Rath-bone-place-water, relatively to the quantity of calca earth contained in that water, was about twice as much uſually combined with an equal quantity of calcareous e and that the earth might be precipitated from this wat driving off the gas by heat, or by abſorbing it by the additi lime-water. Does not this ſolution of calcareous earth b confirm a conjecture concerning the analogy of this fluid acids? It ſeems very extraordinary that calcareous earth ſatu with its uſual quantity of gas ſhould be unſoluble in water, that it may be rendered ſoluble, either by depriving it en of this gas, as it is in lime-water, or by uniting it with a ſ abundant quantity of gas, as it is in the water of Rath-b place, *See Phil. Tranſ. for the Year* 1767.

Mr. Lane has diſcovered another inſtance of the diſſol power of gas upon iron, and has, by ſome ingenious ex ments, ſhewn the probability that this metal is diſſolved in mineral waters by means only of that gas. He found that diſtilled water, having been impregnated with the gas ariſing effervefcing or fermenting ſubſtances, was rendered capab diſſolving a ſenſible portion of iron; and that this artificial c beate water, by expoſure to air, loſt entirely its propert tinging an infuſion of galls. As ſeveral chalybeate mi

loaded with greasy and viscid matters, by means of which the salts contained were prevented from crystallizing.

A portion of crystallizable salt, similar to those already extracted, does indeed remain in the mother-waters; and perhaps also the crystallization of these may be impeded by the viscid matters that are sometimes contained in these waters: but generally the greatest part of the matter contained in mother-waters is composed of salts that are deliquescent and different from those already obtained by crystallization. We are certain, at least, that the mother-waters of sea-salt and of nitre are formed almost entirely of these salts, which have a certain kind of adhesion to the crystallizable salts, and which therefore prevent the crystallization of the last portions of these. The mother-water of common salt contains a considerable quantity of marine salt with earthy basis, and the mother-water of nitre contains not only marine salt with earthy basis, but also a considerable quantity of nitre with earthy basis: hence, if a fixed alkali be added to these waters, a white earthy precipitate is formed so copiously, that the whole becomes a kind of paste. By diluting this paste with much water, the earth may be obtained by filtration. The earth when edulcorated is very white, and of a calcareous nature. It is called *magnesia*. *(i)*

If

waters do also, by exposure to air, entirely lose their property of tinging an infusion of galls; and as waters containing iron dissolved by means of vitriolic acid, though a considerable sediment is also deposited from them, do never entirely lose this property; he infers, that the former kind of waters receive their chalybeate impregnation by means, not of an acid, but of this gas. He further shews, from experiments, that iron cannot be so entirely precipitated from its solution in any of the mineral acids by means of mild alkalis, or mild calcareous earth, that this solution shall lose its power of tinging an infusion of galls; but that the iron may be so perfectly precipitated from the above-mentioned solutions by means of caustic alkali, or of lime-water; and hence he infers, that in the former case the portion of iron that is not precipitated is kept suspended or dissolved by means of the gas extricated by the acid of the solution from the mild alkali or earth. *See Phil. Trans. for the Year* 1769.

*(i)* Magnesia is an earth not convertible into quicklime, therefore different from calcareous earth, with which it is sometimes confounded, and is possessed of peculiar properties. *See the article* MAGNESIA, *and the* NOTE *subjoined.*

If vitriolic acid be added to these mother-waters, a copious white precipitate is likewise formed. This p pitate also proceeds from the union of this acid wit calcareous earth of the earthy salts, by which a seleni formed. The selenites, not being soluble in so sm quantity of water as that of the mother-water employe mostly precipitated in form of an earthy sediment cons of very minute crystals. *See* SALTS *with* EARTHY B *and* MAGNESIA.

WATER *of* RABEL. The water of Rabel i triolic acid dulcified by mixture with rectified spirit of Rabel, the inventor of this liquor, which is used i dicine, employed an expensive apparatus in the prepa of it. He obtained the vitriolic acid from pyrites: since his time, the process has been much simplified, ought to be. One part of oil of vitriol is mixed three parts of rectified spirit of wine, and the mixtu digested in a well-closed vessel. The vitriolic acid upon all the principles of the spirit of wine, and com with them in a certain degree during this digestion: the acidity of the liquor is considerably diminished, bu perfectly destroyed. This water of Rabel may be cons as a dulcified vitriolic acid. *See* ETHER.

Water of Rabel is employed in medicine as an a gent, from the property which the vitriolic acid constringing the fibres and vessels. It requires to be ed in some proper vehicle, as in potions or juleps.

WATER (SEA). Sea-water, and the waters of salt-lakes, wells, and springs, containing various kin salts, is in much greater quantity than fresh-water.

We may say in general, that all natural salt-waters tain several kinds of salts, namely, common salt, ber's salts, selenites, Epsom salts, and marine salt earthy basis. These salts are in different quantitie proportions, according to the nature of the waters; b quantity of the common salt is always greater tha of any other.

All these waters have a saline, and more or less acrid, bitter taste. The acrimony and bitterness of waters are generally attributed to the bituminous m

The mother-waters of common salt and of nitre do also c some marine and nitrous salts with basis of calcareous ea appears from the formation of selenites upon adding vi acid, as is mentioned in the following paragraph of the te

sup

ſuppoſed to be contained in them: but I can affirm, that I have made many experiments on large quantities of theſe ſeveral waters, and that I could never find any ſenſible quantity of bitumen. The bitterneſs, therefore, of theſe waters ought to be attributed to the Glauber's ſalt, which is bitter, and eſpecially to the marine ſalt with earthy baſis, which is very bitter and acrid.

This notion of a bitumen being diſſolved in ſea-water has induced an opinion, that this water could not be rendered perfectly ſweet and fit for drinking merely by diſtillation, without ſome intermediate ſubſtance: and ſome authors, otherwiſe very intelligent, have recommended to mix with the ſea-water different ingredients, which they ſuppoſed fit to retain this bitumenous matter. Nevertheleſs, all the water that falls from the clouds, and all that flows on the ſurface of the earth and quenches the thirſt of animals, is nothing but ſea-water diſtilled and rendered ſweet, without any intermediate ſubſtance, by a natural evaporation. I am convinced from experience, that by means of a ſimple diſtillation, ſea-water may be rendered perfectly like the beſt river-water diſtilled. This truth appears from the following fact.

About twenty or twenty-five years ago, a ſtranger acquainted the Miniſter of the Marine department, that he was poſſeſſed of a ſecret to make ſea-water freſh, for the uſe of ſhips. The Miniſter ſent him to the Academy of Sciences in order to verify his proceſs. The Academy named Meſſrs. Bourdelin, Galiſſonier, and myſelf, to perform this office. The operation was made in my laboratory with ſea-water, brought purpoſely from Diepe, and which had been taken four leagues from land. The Author of the ſecret mixed with the part of this water which was to be purified from ſalt, a conſiderable quantity of white powder, which looked like ſlaked quicklime or powdered chalk, and the mixture was diſtilled in an alembic. We obtained a water perfectly ſweet, and which had all the properties of the beſt diſtilled water. As at that time I believed in the pretended bituminous matter of ſea-water, I wondered much at this proceſs, and I intended to make an advantageous report of it to the academy. Nevertheleſs, I thought it would be proper, firſt to diſtill the remainder of the ſea-water without any intermediate ſubſtance, which I accordingly did in the ſame alembic previouſly well waſhed. I conducted the diſtillation with a moderate fire, and with all the neceſſary attentions to procure

cure a pure and unmixed product, and I obtained a
ſiderable quantity of water as good, and which ſtoo
the teſts, as well as the water which had been dif
with the intermediate ſubſtance. I put ſome of this
into bottles, ſimilar to thoſe which contained the
diſtilled with the intermediate ſubſtance, and having
ſented both of them to the author of the ſecret, wi
telling him what I had done, he could not, upon ta
it and making the moſt accurate trials of it, find
difference between the two waters. I then declared to
and to the members of the Academy, who were pr
the manner in which I had diſtilled the water. The p
were repeated with the greateſt care: And the author
took leave without ſaying a word, and I have not hea
him ſince. I have ſince that time had an opportuni
examining a ſalt-water, which we might expect to b
moſt bituminous of all; I mean the water of the lak
*phaltus*, or the *dead-ſea*. M. Guettard having ſent to the
demy of Sciences ſeveral bottles of this water, which h
received from an intelligent traveller and good natur
Meſſrs. Lavoiſier, Sage, and I, were appointed to exa
it. The reſult of our experiments on this water whic
found to be very ſalt, heavy, acrid, and bitter, was,
we obtained from it a good deal of common ſalt, of w
a part had cryſtallized in the bottles, but eſpecially, a
digious quantity of marine ſalt with earthy baſis, and
it gave no marks of its containing bitumen. *(k)*

Sea-

*(k)* It has been long known that a freſh water may be e
rated from the ſea, and that the ſaline part was chiefly left be
On this principle, the common art of making ſalt, by fo
by artificial heat, is founded. The ancient navigators, ac
ing to Pliny, were uſed, when their freſh water was ſcarc
avail themſelves of the natural evaporation of freſh water
the ſea. *Quia ſæpe navigantes defectu aquæ dulcis laborant
quoque ſubſidia demonſtrabimus. Expanſa circa navim veller
deſcant, accepto halitu maris, quibus humor maris exprimitur.*

But although the general principle was known, a prej
univerſally prevailed, that the water obtained by diſtillati
ſea-water, ſtill remained impregnated with too much of a
or bituminous ſubſtance, to be uſed for the purpoſe of supp
the want of freſh water at ſea. This prejudice probably
from the diſtillation having been extended too far; for whe
greateſt part of the ſea-water is evaporated, the remaining li
being a highly concentrated brine, and of a greater denſity

Sea-water is not every where impregnated with an equal quantity of ſalt. Generally, it has been obſerved to contain more ſalt in hot than in cold climates. The quantity of common ſalt contained in ſea-water is to the quantity of that water as three or four to a hundred. The water is conſequently far from being ſaturated with that ſalt; for water is capable of diſſolving nearly a fourth part of its weight of common ſalt.

Common ſalt is obtained from ſea-water by evaporation alone, and not by alternate evaporation and cooling; becauſe this ſalt is equally ſoluble in cold as in hot water. *See* CRYSTALLIZATION, *and* SALT (COMMON).

In the ſouthern provinces of France, and in all equally hot or hotter climates, ſea-water is evaporated in open air, and merely by the heat of the ſun in ſummer, by which means the common ſalt is obtained. For this purpoſe,

water, is capable of receiving a ſo much greater degree of heat than was at firſt neceſſary to make the water boil, that not only the watery vapor, but alſo ſome of the ſaline parts, are raiſed in diſtillation. To prevent the exhalation of the ſaline part of the ſea-water in diſtillation, various propoſals were ſuggeſted of adding intermediate ſubſtances; as *lapis infernalis*, calcined bones, ſoap leys, powdered chalk, &c. and theſe methods were ſucceſſively tried, and abandoned. The poſſibility, however, of obtaining a perfectly freſh water from ſea-water merely by diſtillation without intervention of other ſubſtances, did not eſcape the Author of the Dictionary, as is above related, nor the zealous and ſucceſsful reſearches of Dr. James Lind, Phyſician to the Royal Hoſpital at Haſlar, to promote in every reſpect the health of ſeamen. This Gentleman publicly demonſtrated in the year 1761, by ſeveral trials and experiments, that a ſimple diſtillation rendered ſea-water perfectly freſh, pure and wholeſome; and in May 1762, an account of this diſcovery was read to the Royal Society, and was ſoon afterwards publiſhed by authority of the Lords of the Admiralty. Nevertheleſs, the diſtillation of freſh water from ſea-water was not brought into general uſe, whether from the inconvenience of keeping and employing an apparatus for diſtilling on board of ſhips, ſufficiently large for the purpoſe required, or from the too great expence of fuel, or from the prejudices of mankind againſt new improvements; till Dr. *Charles Irving* invented a method of applying the *Ship's kettle*, or veſſel commonly employed for cooking victuals, to the purpoſe of diſtilling freſh water, without any other additional apparatus than that of a copper tube bent nearly at right angles. The ſea-water to be diſtilled was put into this kettle, which was therefore

pose, large basons are made in the ground near the
called salt-marshes. They are so disposed that the
water may flow into them at certain tides, and be re
ed there. These marshes are divided into many com
ments, communicating with each other, into which
required quantity of water may be admitted. The
in these is of a small depth, that the evaporation ma
vance more quickly. When the water is sufficiently
porated, and the salt is crystallized, more water is ad
ted, till a sufficient quantity of salt is obtained, whi
then gathered in heaps and drained.

In the northern provinces of France common salt is
tained from sea-water in the following manner:

A quantity of sand moistened with sea-water is exp
to the sun and dried, which is quickly done, becaus
sea-water is almost entirely near the surface of the
The sand, which then becomes covered with a conside
quantity of salt, is to be washed with as much water

therefore employed as the body of a still; and into the mou
the kettle was fitted the shorter leg of the tube, while the l
leg served to condense the steam during its passage throug
and to convey the condensed water into any vessel placed a
extremity of the tube to receive this water. In order to ac
rate the condensation, he recommends to wet the tube freq
ly with a mop; by which means a continual evaporation
the external surface of the tube might be produced, much
might consequently be carried off, and the vapor withi
tube might be cooled and condensed. By this very simple a
ratus, he shews that a great quantity of fresh water may b
tained with an inconsiderable expence of fuel, with little
ble, and without any cumbersome vessels. He particularl
structs that only three-fourths of the sea-water should be dist
as the water distilled from the remaining concentrated bri
found to have a disagreeable taste, and as the further con
ance of the distillation is apt to be injurious to the vessels.
experience of those ships in which this method has been
practised during long voyages, has evinced its utility, and
lity of execution. *See a journal of a voyage towards the*
*Pole, by the Honourable Captain Phipps*, to which is added a
*pendix*, giving a description of Dr. Irving's apparatus, wit
account of its success during that voyage.

Dr. *Priestly* has suggested a proposal to give to this dis
water *the briskness and spirit of fresh spring water*, and a
same time of rendering it perhaps a *remedy* or *preventative* ag
the *scurvy*, by *impregnating it with the gas or fluid called fixe*
obtained by mixing chalk with oil of vitriol.

nece

neceſſary for the ſolution of the ſalt adhering to it; and this water is afterwards evaporated over the fire in leaden cauldrons, till the ſalt is cryſtallized.

Wallerius ſays, that in the northern countries the ſalt in ſea-water is concentrated by expoſure to intenſe cold, by which means great part of the water is frozen, and the unfrozen part, which contains almoſt all the ſalt, is afterwards evaporated by fire, till the ſalt is cryſtallized.

After the common ſalt has been thus obtained by theſe operations from ſea-water, a liquor, called *mother-water*, remains, that contains much ſalt, which cannot be cryſtallized. If this water be further evaporated, and then expoſed to cold, a certain quantity of Glauber's ſalt, and Epſom ſalt will be obtained.

Laſtly, the remaining part of the mother-water contains ſcarcely any thing but marine ſalt with earthy baſis, the earthy part of which may be precipitated by an alkaline lixivium. This earth is called the *Magneſia of common ſalt. See* WATER (MOTHER), *and* MAGNESIA.

WATER *of* SALT-SPRINGS. The water of almoſt all ſalt-ſprings, at leaſt of thoſe from which common ſalt is obtained, contains exactly the ſame principles as ſea-water, but generally in a larger quantity. Some of theſe ſprings contain ſixteen pounds of ſalt in a hundred pounds of water. Such, for inſtance, is that of Dieuſe in Lorraine, one of the beſt ſalt-works known. Other ſprings contain a much ſmaller proportion of ſalt; ſuch is that of Montmorat in Franche-compté.

Salt is obtained from theſe ſalt-ſprings generally by evaporation over the fire; at leaſt, it is ſo in Lorraine, and in Franche-compté: but that the expence of fuel may be leſſened, the water, when weakly impregnated, is previouſly concentrated by frequently pouring it upon bundles of twigs or faggots under buildings that are covered, but open at all the ſides, called *graduating houſes*. The water raiſed by pumps to the top of theſe buildings falls upon the faggots, by which it is divided into a ſhower, its ſurface is thereby encreaſed, and the evaporation is promoted by the free current of air that paſſes through the open ſides of the building. When, by this means, the water is ſo concentrated that a hundred pounds of it contain about thirteen or fourteen pounds of ſalt, it is then evaporated over the fire in the uſual manner.

As theſe waters are much more impregnated with ſaline principles than ſea-water, and as their evaporation is more quickly

quickly finiſhed, we ſhall confirm what we have ſaid c
cerning the evaporation and formation of the ſeveral
in ſea-water, by deſcribing the method employed in
evaporation of the water of the ſalt-ſprings of Lorraine
Franche-compté.

This water is evaporated in very large veſſels mad
plates of iron, capable of containing from eight to nin
ten thouſand gallons of water, called *ſalt-pans*, the d
of which is about fifteen or ſixteen inches.

In theſe the water is boiled ſome time, during whi
ſaline earthy matter, called *ſchlot* or *ſcratch*, is depoſ
and is carefully to be ſeparated. This ſcratch is a ſelen
which of all the ſaline matters contained in the wat
the leaſt ſoluble, and conſequently cryſtallizes firſt.
ſelenites draws along with it ſome of the other ſalts,
principally Glauber's ſalt, which ſeems to have ſome
gree of adheſion to it.

When the ſelenites is ſeparated, the common ſalt, b
in greater quantity than the other ſalts, begins to cry
lize and form cubes. That larger cryſtals of this ſalt
be formed, the water is made to boil very ſlowly, til
common ſalt ceaſes to cryſtallize. The water that rem
is very heavy, much impregnated with ſalt, of an a
and bitter taſte. This is the *mother-water*.

This mother-water contains ſtill ſome common
ſome Glauber's ſalt, and eſpecially a large quantity of
rine ſalt with earthy baſis. The Glauber's ſalt rem
chiefly in the mother-waters, becauſe it is much more
ble in hot than in cold water, and cryſtallizes more rea
by cold than by evaporation. The marine ſalt with ea
baſis remains almoſt entirely in the mother-water, bec
it is deliqueſcent, and not ſuſceptible of a true cryſt
zation. *See* WATER (MOTHER).

The ſeveral ſalts contained in waters of ſalt-ſpring
thus ſeparated from each other: but this ſeparation is
very accurate. To render it more complete, other m
muſt be employed. The fundamental principles of
perfect purification of the ſeveral ſalts confounded t
ther in the ſame water are explained at the article CRYST
LIZATION. To avoid repetitions, we refer to that art
*See alſo the articles* SELENITES, SALT (COMMON), S
*of* EPSOM, SALT *of* GLAUBER, SALT (MARINE)
EARTHY BASIS, WATER (MOTHER), *and* WAT
(MINERAL).

W

WAX. Wax is an oily, concrete matter gathered by bees from plants.

Wax has been long considered as a resin, from some properties common to it with resins. It has the same consistence as resins have, and, like them, it furnishes an oil and an acid by distillation, and is soluble in all oils: but in several respects it differs sensibly from resins. Like these, wax has not a strong aromatic taste and smell, but a very weak smell, and, when pure, no taste. With the heat of boiling water no principles are distilled from it; whereas, with that heat, some essential oil, or, at least, a spiritus rector is obtained from every resin. Further, wax is unsoluble in spirit of wine. If wax be distilled with a heat greater than that of boiling water, it may be decomposed, but not so easily as resins can. By this distillation a small quantity of water is first separated from the wax, and then some very volatile and very penetrating acid, accompanied with a small quantity of a very fluid and very odoriferous oil. As the distillation advances, the acid becomes more and more strong, and the oil more and more thick, till its consistence be such that it becomes solid in the receiver, and is then called *butter of wax*. When the distillation is finished, nothing remains but a small quantity of coal, which is almost incombustible from the want of some saline matter. *See* COAL.

Wax cannot be kindled, unless it be previously heated and reduced into vapors; in which respect it resembles fat oils. The oil and butter of wax may, by repeated distillations, be attenuated and rendered more and more fluid, because some portion of acid is thereby separated from these substances; which effect is similar to what happens in the distillation of other oils and oily concretes: but this remarkable effect attends the repeated distillation of oil and butter of wax, that they become more and more soluble in spirit of wine; and that they never acquire greater consistence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glass vessel open, or carelessly closed, during twenty years, without acquiring a more solid consistence. We may remark, that wax, its butter, and its oil, differ entirely from essential oils and resins in all the above-mentioned properties, and that in all these they perfectly resemble sweet oils. *See* OILS (ESSENTIAL), RESINS, *and* OILS (SWEET EXPRESSED).

We may therefore conclude from what has been said, as Mr Macquer has done in his Elements of Chemistry, and

and in his Memoir upon Oils, that wax only refer
refins in being an oil rendered concrete by an acid
that it differs eſſentially from theſe in the kind of th
which in refins is of the nature of eſſential oils, wh
wax and in other analogous oily concretions, (as but
milk, butter of cocoa, fat of animals, ſperma-ceti,
wax obtained from a tree in Louiſiana) it is of the n
of ſweet, unctuous oils that are not aromatic, anc
volatile, and are not obtained from vegetables by expre

Wax is very uſeful, eſpecially as a better material
any other for candles.

Wax may be deprived of its natural yellow diſagre
color, and be perfectly whitened, by expoſure to the u
action of air and water, by which method the col
many ſubſtances may be deſtroyed.

The art of bleaching wax conſiſts in encreaſing its ſu
For which purpoſe, it muſt be melted with a degree of hea
ſufficient to alter its quality, in a cauldron ſo diſpoſed
the melted wax may flow gradually through a pipe at the
tom of the cauldron into a large tub filled with water, in w
is fitted a large wooden cylinder, that turns continually r
its axis, and upon which the melted wax falls. As the
face of this cylinder is always moiſtened with cold w
the wax falling upon it does not adhere to it, but qu
becomes ſolid and flat, and acquires the form of ribb
The continual rotation of the cylinder carries off
ribbands as faſt as they are formed, and diſtributes
through the tub. When all the wax that is to be wh
ed is thus formed, it is put upon large frames covered
linen cloth, which are ſupported about a foot and a
above the ground, in a ſituation expoſed to the air,
dew, and the ſun. The thickneſs of the ſeveral ribb
thus placed upon the frames, ought not to exceed
inch and a half; and they ought to be moved
time to time, that they may all be equally expoſed t
action of the air. If the weather be favorable, the
will be changed in the ſpace of ſome days. It is th
be re-melted and formed into ribbands, and expoſ
the action of the air as before. Theſe operations a
be repeated till the wax be rendered perfectly white,
then it is to be melted into cakes, or formed into car

The yellow color of the wax is evidently deſtroyed b
combined action of the air, of the water, and of the ſun.
the volatile, ſulphureous acid has the property of def
ing ſtill more quickly almoſt all the colors of vegeta

per

perhaps this bleaching might be shortened by exposing ribbands of yellow wax to the vapor of sulphur, as is practised for wool and silk. *(l)*

Every kind of wax is not equally capable of being whitened, the color of some adhering so strongly, that it cannot be effaced. Such is the wax that comes from countries in which vines grow. This observation I have received from Mr. Trudon, proprietor of the manufactory of wax at Antoni, near Paris.

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient, and relaxing remedy: but it is only used externally, mixed with other substances. It is an ingredient in many pomatums,

*(l)* The above operation of bleaching wax can be performed well in fine weather only, as it depends chiefly on the action of the sun. This circumstance being attended with much inconvenience to the manufacturers, the discovery of a method of whitening wax, independantly of the seasons, would be very useful, and has been recommended to the attention of chemists by some economical Societies. With a view to discover such a method, Mr. *Beckman* has made experiments, an account of which is published in the 5th volume of the *Novi commentarii Societatis regiæ Scientiarum Gottingensis*. According to these experiments, thin pieces of yellow wax were whitened and hardened by being digested and boiled in diluted and undiluted nitrous acid in a few hours. But the wax thus whitened being melted by means of boiling water, was observed to acquire a yellow color, less intense, however, than it was before it had been treated with the mineral acids. The marine and vitriolic acids were less effectual than the nitrous. He exposed wax to the flames of burning sulphur, but without success. Yellow wax being melted in vinegar was rendered of a grey color. The oil of tartar whitened wax, but less effectually than acids had done; and this wax being washed in water and afterwards digested in nitrous acid was rendered still more white; but upon melting it in water, a yellowish tinge returned. He liquefied wax in solutions of nitre and alum, but without any good effect. Spirit of wine, which is recommended by Boyle for this purpose, did indeed whiten the wax, but changed the wax to a butyraceous substance, so frothy that its bulk was encreased thirty times. Reflecting that tartar is purified from its oily particles by means of a calcareous earth, he tried the effects of a kind of Fuller's earth, which he threw upon wax liquefied in water, and he agitated the mixture. This method rendered wax of a greyish color, and is therefore recommended by him as preparatory to bleaching, the time necessary for which, he thinks, may be thus greatly shortened.

cerates, ointments, and plasters, to most of which it the due consistence. Upon this subject may be con Mr. Beaumé's Elements of Pharmacy, a work conta many excellent observations.

WEIGHTS. *(m)*

WHEY. *See* MILK.

WHITE (SPANISH). This name is given t different substances, namely, the *magistery of bismuth* the washed *chalk* used for painting in water-colors.

WHITE-LEAD. This name is given to the rust produced by exposing lead to the vapors of vinega is also called *cerus*s. *See* CERUSS.

WINE. Chemists give the name of *wine* in gen all liquors that have become spirituous by ferment Thus *cyder*, *beer*, *vinous hydromel*, or *mead*, and othe lar liquors, are wines.

The principles and theory of the fermentation whic duces these liquors are essentially the same. The mo

*(m)* WEIGHTS. As the weights mentioned in this Dic are French, it is proper to explain them, and compare the the English.

The *Paris pound* contains 2 marks, and is to the Engli pound as 21 to 16. It is equal to 7560 troy grains.

The *Paris marks* contains 8 Paris ounces.

The *Paris ounce* contains 8 Paris drams, or gros; and i to 472 $\frac{1}{2}$ troy grains.

The *Paris dram*, or *gros*, contains 3 Paris scruples, or d and is equal to 72 Paris grains, or to 59 $\frac{1}{2}$ troy grains.

The *Paris scruple* or *denier* contains 24 Paris grains, and i to 19 $\frac{11}{48}$ troy grains.

The *Paris grain* is the $\frac{1}{9216}$th part of a Paris pound, a the troy grain as 7560 to 9216.

The *English troy pound* contains 12 ounces,

The *Troy ounce* contains 20 pennyweights.

The *Troy pennyweight* contains 24 grains.

The *English medicinal* or *Apothecary's pound* is the same troy pound, but is otherwise divided.

The *Apothecary's pound* contains 12 ounces.

The *Apothecary's ounce* contains 8 drams.

The *eram* contains 3 scruples.

The *scruple* contains 20 grains.

The *grain* is the same as the troy grain.

The *Averdupoise pound* contains 16 averdupoise ounces, equal to 7004 troy grains, or is to the troy pound as 107 nearly.

neral principles we have explained under the article FERMENTATION. At the articles BEER and HYDROMEL may be found ſome peculiarities relative to theſe kinds of wines. In the preſent article we ſhall chiefly attend to the *wine of grapes*, to which the name of *wine* is more particularly applied. At the ſame time, we ſhall not neglect any thing relating to ſpirituous fermentation in general.

All vegetable and animal matters, which have a taſte ſweet, agreeable, and more or leſs ſaccharine, and which are nutritive, are ſuſceptible of the ſpirituous fermentation. Thus wine may be made of all the juices of plants, the ſap of trees, the infuſions and decoctions of farinaceous vegetables, the milk of frugivorous animals, which is poſſeſſed of the above-mentioned qualities; and, laſtly, it may be made of all ripe ſucculent fruits, which alſo are poſſeſſed of theſe qualities; but all theſe ſubſtances are not equally proper to be changed into a good and generous wine.

As the production of ardent ſpirit is the reſult of the ſpirituous fermentation, we may conſider that wine as eſſenſentially the beſt which contains moſt of this ſpirit. But of all ſubſtances ſuſceptible of the ſpirituous fermentation, none is capable of being converted into ſo good wine, as the juice of the grapes of France, or of other countries that are nearly in the ſame latitude, or in the ſame temperature. The grapes of hotter countries, and even thoſe of the ſouthern provinces of France, do indeed furniſh wines that have a more agreeable, that is, more of a ſaccharine taſte; but theſe wines, though they are ſufficiently ſtrong, are not ſo ſpirituous as thoſe of the provinces near the middle of France: at leaſt, from theſe latter wines the beſt vinegar and aqua vitæ are made. As an example, therefore, of ſpirituous fermentation in general, we ſhall deſcribe the method of making wine from the juice of the grapes of France.

This juice, when newly expreſſed, and before it has begun to ferment, is called *muſt*, and in common language *ſweet wine*. It is turbid, has an agreeable and very ſaccharine taſte. It is very laxative, and when drank too freely, or by perſons diſpoſed to diarrhæas, it is apt to occaſion theſe diſorders. Its conſiſtence is ſomewhat leſs fluid than that of water, and it becomes almoſt of a pitchy thickneſs when dried.

When the muſt is preſſed from the grapes, and put into a proper veſſel and place, with a temperature from ten or twelve degrees to fifteen or ſixteen, very ſenſible effects

are produced in it, in a ſhorter or longer time, ac
to the nature of the liquor, and the temperature of th
It then ſwells, and is ſo rarefied, that it frequent
flows the veſſel containing it, if this be nearly fu
inteſtine motion is excited among its parts, accor
with a ſmall hiſſing noiſe and evident ebullition
bubbles riſe to the ſurface, and, at the ſame time
engaged a vapor which is probably of a phlogiſtic
and is ſo ſubtle and dangerous, that it is capable of
inſtantly men and animals expoſed to it in a place w
air is not renewed. In its effects this vapor is fi
that of burning charcoal. The ſkins, ſtones, ar
groſſer matters of the grapes, are buoyed up by the
of diſengaged air that adhere to their ſurface, are
agitated, and are raiſed in form of a ſcum or ſoft and
cruſt that covers the whole liquor. During the fe
tion this cruſt is frequently raiſed, and broken b
diſengaged from the liquor, which forces its way
it: afterwards the cruſt ſubſides, and becomes e
before.

Theſe effects continue while the fermentation
and at laſt gradually ceaſe: then the cruſt being n
ſupported, falls in pieces to the bottom of the liqu
this time, if we would have a ſtrong and generous
ſenſible fermentation muſt be ſtopt. This is done b
the wine into cloſe veſſels, and carrying theſe into
or other cool place.

After this firſt operation, nature tends ſpontaneo
kind of reſt, as is indicated by the ceſſation of th
effects of the ſpirituous fermentation; and thus
us to preſerve a liquor no leſs agreeable in its ta
uſeful for its reviving and nutritive qualities wh
moderately.

If we examine the wine produced by this firſt f
tion, we ſhall find that it differs entirely and eſſenti
the juice of grapes before fermentation. Its ſweet
charine taſte is changed into one that is very
though ſtill agreeable, and ſomewhat ſpirituous and
It has not the laxative quality of muſt, but affects
and occaſions, as is well known, drunkenneſs.
if it be diſtilled, it yields, inſtead of the inſipid w
tained from muſt by diſtillation with the heat o
water, a volatile, ſpirituous, and inflammable liqu
*ſpirit of wine*, or *ardent ſpirit*. This ſpirit is con

being, produced by the kind of *fermentation* called *ous* or *ſpirituous*. *See* SPIRIT (ARDENT).

on one ſide, the liquors ſuſceptible of the ſpirituous tation contain chiefly a ſweet oil rendered miſcible ater by means of an acid; and as, on the other ſide, uor produced by the ſpirituous fermentation is inflam- but ſtill miſcible with water, and conſequently ſed of a watery and inflammable principle; we may erceive, that the work of nature chiefly conſiſts in ting, dividing, and volatiliſing the oily parts of fer- le matters, and in combining theſe intimately with tery principle. But by what mechaniſm does nature this change? In what does attenuation of the oily ecifely conſiſt? In what proportion is this oil, or s inflammable principle, united with the watery prin- the compoſition of ardent ſpirit? Theſe are myſteries re that are ſtill entirely hid from us, and which we eaſily explain. Without entering, therefore, into lation concerning the production of ardent ſpirit, ll proceed in the hiſtory of ſpirituous fermenta-

en any liquor undergoes the ſpirituous fermentation, parts ſeem not to ferment at the ſame time, otherwiſe nentation would probably be very quickly compleated, e appearances would be much more ſtriking: hence, quor much diſpoſed to fermentation, this motion is quick and ſimultaneous than in another liquor leſs d. Experience has ſhewn, that a wine, the fermen- of which is very ſlow and tedious, is never good ery ſpirituous; and therefore, when the weather cold, the fermentation is uſually accelerated by the place in which the wine is made. A pro- which I think is a good one, has been made by a very intelligent in economical affairs, to employ a than the uſual heat to accelerate the fermentation of in thoſe years in which grapes have not been ſuffi- ripened, and when the juice is not ſufficiently diſ- o fermentation.

o haſty and violent fermentation is perhaps alſo hurt- om the diſſipation and loſs of ſome of the ſpirit: but s we are not certain. However, we may diſtinguiſh, ordinary method of making wines of grapes, two s in the fermentation, the firſt of which laſts during pearance of the ſenſible effects above-mentioned, in the greateſt number of fermentable particles do fer-

 ment.

ment. After this firſt effort of fermentation, theſ
ſenſibly diminiſh, and ought to be ſtopped, for reaſo
after to be mentioned. The fermentative motion
liquors then ceaſes. The heterogeneous parts th
ſuſpended in the wine by this motion, and which
it muddy, are ſeparated, and form a ſediment ca
lees; after which the wine becomes clear: but a
the operation be then conſidered as finiſhed, and
mentation apparently ceaſes, it does not really ceaſe
ought to be continued in ſome degree, if we wou
good wine. In this new wine a part of the liquor
that has not fermented, and which does afterwards
but ſo very ſlowly, that none of the ſenſible effe
duced in the firſt fermentation are here perceived
fermentation, therefore, continues ſtill in the wine,
a longer or ſhorter time, although in an imper
manner; and this is the ſecond period of the ſpiritu
mentation, which may be called the *imperceptible f*
*tion*. We may eaſily perceive, that the effect of
perceptible fermentation is the gradual encreaſe
quantity of ſpirit in wine. It has alſo another
leſs advantageous, namely, the ſeparation of a ſalin
earthy matter, called *tartar*, from the wine. Thi
is therefore a ſecond ſediment that is formed in t
and which adheres to the ſides of the containing
As the taſte of tartar is harſh and diſagreeable, it i
that the wine, which, by means of the inſenſible
tation, has acquired more ſpirit, and has diſengag
of the greateſt part of its tartar, ought to be muc
and more agreeable; and for this reaſon chiefly, ol
univerſally preferable to new wine.

But inſenſible fermentation can only ripen and
the wine, if the ſenſible fermentation has regul
ceeded, and has been ſtopped in due time. W
certainly, that if a ſufficient time has not been all
the firſt period of the fermentation, the unfermente
that remains, being in too large a quantity, will then
in the bottles, or cloſe veſſels in which the wine is
will occaſion effects ſo much more ſenſible, as
fermentation ſhall have been ſooner interrupted
theſe wines are always turbid, emit bubbles; and ſo
break the bottles, from the large quantity of air an
that are diſengaged during the fermentation. We
inſtance of theſe effects in the white wine of Cha
and in others of the ſame kind. The ſenſible ferm

ese wines is interrupted, or rather suppressed, that they have this sparkling quality. It is well known that wines make the corks fly out of the bottles, that they le and froth when they are poured into glasses, and, , that they have a taste much more lively and more ant than wines that do not sparkle; but this sparkling ty, and all the effects depending on it, are only caused considerable quantity of air which is disengaged during onfined fermentation which the wine has undergone in vessels. This air, not having an opportunity of ing, and of being dissipated as fast as it is disengaged, being interposed betwixt all the parts of the wine, bines in some measure with these, and adheres in the manner as it does to those mineral waters that are called tuous, in which it produces nearly the same effects. en this air is entirely disengaged from these wines, they onger sparkle, they lose their piquancy of taste, become , and even almost insipid.

ch are the qualities that wine acquires in time, when irst fermentation has not continued sufficiently long. se qualities are given purposely to certain kinds of wine, ndulge taste or caprice; but such wines ought not to aily drank. Wines for daily use ought to have under- so compleatly the sensible fermentation, that the suc- ing fermentation should be insensible, or, at least, ex- ingly little sensible. Wine, in which the first fermen- n has been too far advanced, is liable to worse incon- ences than that in which the first fermentation has been quickly suppressed; for every fermentable liquor is from ature in a continual fermentative motion, more or less ng, according to circumstances, from the first instant of spirituous fermentation, till it is compleatly putrefied: ce from the time of the completion of the spirituous entation, or even before, the wine begins to undergo acid or acetous fermentation. This acid fermentation is slow and insensible when the wine is included in very e vessels, and in a cool place; but it does gradually nce, so that in a certain time the wine, instead of being orated, becomes at last sour. This evil cannot be edied, because the fermentation may advance, but not be reverted. Wine-merchants, therefore, when r wines become sour, can only conceal or absorb this ity by certain substances, as by alkalis and absorbent hs. But these substances give to wine a dark-greenish r, and a taste, which, though not acid, is somewhat

 disagreeable.

is somew
disagreeable

diſagreeable. Beſides, calcareous earths accelerate
ſiderably the total deſtruction and putrefaction of the
Calxes of lead, having the property of forming with th
of vinegar a ſalt of an agreeable ſaccharine taſte, which
not alter the color of the wine, and which beſides ha
advantage of ſtopping fermentation and putrefaction, r
be very well employed to remedy the acidity of wi
lead and all its preparations were not pernicious to h
as they occaſion moſt terrible colics, and even death,
taken internally. We cannot believe that any wine-
chant, knowing the evil conſequences of lead, ſhoul
the ſake of gain, employ it for the purpoſe mentioned
if there be any ſuch perſons, they muſt be conſidered
poiſoners and murderers of the public.

If wine contains litharge, or any other calx of le
may be diſcovered by evaporating ſome pints of it to dr
and melting the reſiduum in a crucible, at the bott
which a ſmall regulus of lead may be found after the f
but an eaſier and more expeditious proof is by pourin
the wine ſome liquid liver of ſulphur. If the preci
occaſioned by this addition of the liver be white, o
colored by the wine, we may know that no lead is
tained: but if the precipitate be dark-colored, brow
blackiſh, we may be certain that lead is contained.

The only ſubſtances that cannot abſorb or deſtroy
cover and render ſupportable the ſharpneſs of wine, wi
any inconvenience, are ſugar, honey, and other sacc
alimentary matters; but they can ſucceed only whe
wine is but very little acid; and when an exceeding
quantity only of theſe ſubſtances is ſufficient to produ
deſired effect; otherwiſe the wine would have a ſwe
tart, and not agreeable taſte.

From what we have ſaid concerning the aceſcency of
we may conclude, that when this accident happens, it c
by any good method be remedied, and that nothing re
to be done with ſour wine but to ſell it to vinegar-m
as all honeſt wine-merchants do. We may obſerve,
the firſt ſenſible fermentation having been too far adva
is not the only cauſe of the acidity of wine, but
heat alſo is capable of producing the ſame effect.
wine, which might have been long preſerved in a
place, very quickly becomes ſour, when placed in
cellar; and even as the beſt cellars have during the
a degree of heat much ſuperior to that of the atmoſ
it would be very proper, when wine diſpoſed to b

is to be preſerved, to bring it from the cellar in the nning of winter, and leave it expoſed to the air during hat ſeaſon.

Vine is alſo liable to other changes; as, to become and mucilaginous, by the continuance of the fermen- e motion: but we cannot proſecute theſe details in a of this kind. Beſides, the ſpirituous fermentation, its conſequences, ſtill require a further examination, h we hope will be performed in a ſatisfactory manner, ſeveral Academies, ſenſible of the importance of the ect, have offered prizes for diſcoveries relative to it. that we can at preſent ſay is, that the fundamental ciples from which we may deduce a more accurate vledge on this ſubject, may be diſcovered by deter- ng with what degree of heat, and during what time, irſt ſenſible fermentation of muſt ought to be promoted, the moſt ſpirituous and beſt keeping wine may be ined. I confeſs that this object is very extenſive, and difficult to be known in a general manner, conſider- how variable theſe things are, and what differences, aps greater than we now imagine, there ought to be, rding to the nature of the muſt, which varies exceed- y in different countries, and at different times. Expe- ce and obſervation have already inſtructed makers of e in many things relative to this ſubject; but much yet ains to be determined, which is not within the reach of nary country people, or even of the proprietors of the t vine-yards.

Vine, and the matters produced from wine, as brandy, it of wine, vinegar, lees of wine, tartar, are greatly extenſively uſeful. The lees of wine are employed in manufacture of hats. Theſe lees, and alſo tartar by neration, yield a larger quantity than any other vege- le matter of pure fixed alkali. *See the articles* AQUA TÆ, SPIRIT *of* WINE, TARTAR, *and* VINEGAR.

Wine has been preferred in all times and in all countries very other alimentary liquor. We may ſay in general, t it is good and ſalutary when taken in ſmall quantities, that it is pernicious when drank habitually, and in large quantities. Wine becomes then a true ſlow ſon, which is ſo much more dangerous, as it is more eeable. But if we obſerve more particularly the effects wine, we ſhall perceive very great differences depending different conſtitutions. Some perſons drink habitually ge quantities of pure wine, without any ſenſible incon- venience

venience or diſeaſe, or ſhortening their lives: but,
contrary, many others do alſo entirely deſtroy their
and ſhorten their lives, by an habitual uſe of wine
ſmall quantity, and mixed with water. Althoug
always more ſafe and prudent for every perſon to
little of it habitually, this moderation is more indiſp
neceſſary to thoſe whoſe conſtitutions wine does not

As the diſeaſes conſequent upon the too free uſe o
come gradually and inſenſibly, ſometimes even durin
years, ſeveral perſons, eſpecially men, otherwiſe ver
and attentive to health, are every day deceived up
article, drinking more wine than is ſuitable to the
ſtitution, and gradually ruining their health without
ing the cauſe. It is therefore a matter of import
ſhew the ſigns by which wine may be known to be b
We may know that wine does not ſuit a perſon, whe
drinking moderately of it, his breath acquires a
ſmell; when it occaſions ſour belchings and ſligh
in the head; and when, after drinking it more co
than uſual, it produces ſtupefaction, nauſea, and dr
neſs, eſpecially when this drunkenneſs is of the
peeviſh, quarrelſome, and iraſcible kind. Unhappy
perſon who ſuffers theſe effects from wine, and n
ſtanding contracts and perſiſts in the habitual uſe
Theſe imprudent perſons do never fail of comin
miſerable death, preceded by languor, and pren
their common age being about fifty years, or a littl
The diſeaſes to which they are moſt ſubject are obſtr
in the liver, in the meſenteric glands, and in other abo
viſcera, which are almoſt always ſucceeded by an in
dropſy. Thoſe who digeſt wine well, do not ſu
much leſs ſenſibly, the above-mentioned effects of d
it. Their drunkenneſs is accompanied with vivac
joy. Such perſons ſeldom die of the obſtructio
dropſy above-mentioned: but wine is nevertheleſs
more dangerous to them, that as they ſuffer none of
agreeable effects, they are more liable to contract th
of drinking too much. Drinkers of this claſs ge
live ſomewhat longer than the former; but their co
tion generally changes before ſixty years of age;
inheritance of their old age is either a ſevere gout o
ſtupidity, imbecillity, or an accumulation of theſe

We need not mention that the too frequent uſe of
ratafia, and of other ſpirituous liquors is ſtill muc
pernicious and fatal than of wine.

Vine is uſed in medicine as a vehicle in the compoſition
any internal and external remedies. As wine is com-
d of an ardent ſpirit, water, extractive ſaponaceous
er, and acid of tartar, it may be very uſefully employed
he extraction of almoſt all the proximate principles,
conſequently of the medicinal parts, of vegetables.
y extracts are made with wine, which may be conſidered
eing more compleat than thoſe made with water: but
icians who preſcribe theſe extracts ought to remember,
, beſides the principles of the vegetables, they alſo
ain the extractive part of the wine, that is, all the
ciples of wine, excepting the ardent ſpirit, which is too
tile to remain in an extract.

s wine, when good, may be preſerved during a long
, ſeveral medicinal wines preſcribed in Diſpenſatories
kept in the ſhops of apothecaries. Such are the aſtrin-
, antiſcorbutic, febrifugal wines of the Peruvian bark,
wormwood, chalybeate wine, and others. In many
s, as in ſeveral chronical diſeaſes, where tonic, cordial,
ifying and exciting remedies are indicated, phyſicians
er the uſe of wine to water, as a vehicle for the in-
on of purgative, aperitive, and other medicinal ſub-
ces.

WOAD. *(n)*

WOLF-

*n)* Woad. Dr. Lewis, in a note to his edition of Neuman's
emical Works, gives the following account of woad.

*Woad, iſatis, glaſtum,* is a plant with long green leaves; the
er ones narrow at both ends; thoſe which grow upon the ſtalk
broad at bottom like an arrow-head. On the tops come
h numerous yellow flowers, which are followed by little flat
s containing the ſeeds. It grows wild in ſome parts of France,
on the coaſts of the Baltic Sea: the wild woad, and that
ich is cultivated for the uſe of dyers, appear to be the ſame
cies of plant. The preparation of woad for dying, as prac-
d in France, is minutely deſcribed by Aſtruc, in his Memoirs
a Natural Hiſtory of Languedoc. The plant puts forth at
five or ſix upright leaves, about a foot long and ſix inches
ad: when theſe hang downwards, and turn yellow, they are
for gathering: five crops are gathered in one year. The leaves
carried directly to a mill, much reſembling the oil or tan-
lls, and ground into a ſmooth paſte. If this proceſs was de-
red for ſome time, they would putrefy, and ſend forth an in-
portable ſtench. The paſte is laid in heaps, preſſed cloſe and
ooth, and the blackiſh cruſt, which forms on the outſide, re-
ited if it happens to crack: if this was neglected, little worms
would

, litt

would be produced in the cracks, and the woad would lose a p
of its strength. After lying for fifteen days, the heaps are open
the crust rubbed and mixed with the inside, the matter form
into oval balls, which are pressed close and solid in wood
moulds. These are dried upon hurdles: in the sun, they tu
black on the outside; in a close place, yellowish, especially
the weather be rainy: the dealers in this commodity prefer t
first, though it is said the workmen find no considerable differe
betwixt the two. The good balls are distinguished by th
being weighty, of an agreeable smell, and when rubbed, o
violet color within. For the use of the dyer, these balls requ
a further preparation: they are beat with wooden mallets, o
brick or stone floor, into a gross powder; which is heaped up
the middle of the room to the height of four feet, a space bei
left for passing round the sides. The powder, moistened w
water, ferments, grows hot, and throws out a thick fetid fum
It is shovelled backwards and forwards, and moistened every d
for twelve days; after which it is stirred less frequently, witho
watering, and at length made into a heap for the dyer.

The powder thus prepared gives only brownish tinctures,
different shades, to water, to rectified spirit of wine, to volat
alkaline spirits, and to fixed alkaline lixivia: rubbed on pap
it communicates a green stain. On diluting the powder w
boiling water, and after standing some hours in a close vess
adding about one twentieth part of its weight of lime new
slaked, digesting in a gentle warmth, and stirring the whole t
gether every three or four hours, a new fermentation begins,
blue froth arises to the surface, and the liquor, though it appe
itself of a reddish color, dyes woollen of a green, which, like t
green from Indigo, changes in the air to a blue. This is one
the nicest processes in the art of dying, and does not well su
ceed in the way of a small experiment.

Astruc proposes the manufacturing of fresh woad leaves in E
rope, after the same manner as the Indigo plant is manufactur
in America; and thus preparing from it a blue fecula similar
indigo, which from his own experiments he has found to be pra
ticable. Such a management would doubtless be accompani
with some advantages, though possibly, woad so prepar
might lose those qualities which now render it, in a lar
business, preferable on some accounts to indigo, as occasioni
greater dispatch when once the vat is ready, and giving out
color less hastily, so as to be better fitted for dying very lig
shades.

(o) Wolfram, *Spuma lupi*, is a very refractory mineral of
black or dusky color, crystallized in form of cubes, striæ, or oth
determinate shape, and consisting of shining plates. Its appea
an

OOL (PHILOSOPHIC). This is a name by ancient chemical or alchemical authors to flowers nc. *See* FLOWERS *of* ZINC.

ORMWOOD. *(p)*

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ELLOW. *(q)*

is ſimilar to the ore of tin, called tin-grains or cryſtals of tin: t is frequently found in tin-mines. It is ſo hard that it can ſparks from ſteel. When powdered, it is red. Wallerius ders it as an ore of iron mineraliſed by arſenic, which ſome- contains tin. According to Cronſtedt, it is a kind of mag- or manganeſe, containing a ſmall portion of iron and of

) WORMWOOD. The leaves of wormwood are intenſely r, and have a ſtrong ſmell, ſomewhat of the aromatic kind. yield in diſtillation a conſiderable quantity of eſſential oil dark greeniſh color poſſeſſing the whole of their ſmell, the r matter remaining in the extract. *Neuman.*

) YELLOW. A yellow dye may be made from indigo in the wing manner.

ake half an ounce of powdered indigo, mix it in a high glaſs l with two ounces of ſtrong ſpirit of nitre, previouſly di- d with eight ounces of water. Let the mixture ſtand for a c, and then digeſt it in a ſand-bath for an hour or more, and four ounces more of water to it; filter the ſolution, which be of a fine yellow color. Strong ſpirit of nitre is apt to ſet to indigo, and on that account it muſt be diluted with water. o ounces and a half of ſtrong ſpirit of nitre, or leſs highly con- rated, will ſet fire to half an ounce of indigo. The reaſon of ing it ſtand a week before the digeſtion, is to prevent its hing up.

One part of the above ſolution mixed with four or five parts of er will dye cloth or ſilk from the paleſt yellow color to the peſt, by letting the ſtuffs boil more or leſs in the color. The ition of alum makes the color more laſting.

Cochineal, Dutch litmus, orchel, cudbear, and many other oring ſubſtances treated in the manner as indigo is in the ve receipt, will all dye ſilk and wool of a yellow color.

Cloth and ſilk may be dyed green with indigo, by boiling firſt the yellow and then in the blue.

Experiments on Aurum Moſaicum by Mr. P. Woulfe. *Phil. anſ.* 61.

ZAFFRE,

ZAFFRE, *or* SAFFRE. Zaffre is the resid
cobalt, after the sulphur, arsenic, and other
tile matters of this mineral have been expelled by ca
tion. It is therefore a kind of calx of cobalt, of a g
reddish color. The use of cobalt is to produce a ve
blue color, when it is melted with fusible and vitr
matters.

This blue color produced by the vitrification of
proceeds from the earth or calx of a semi-metallic sub
contained in cobalt, called by chemists, *regulus of*
This is proved by melting zaffre with a reducing flux
any other roasted ore; by which means the above-men
semi-metallic regulus of cobalt will be obtained.
scoria in this fusion has also a blue color, which pr
from a portion of the calx of this regulus that is not red
but is vitrified along with the scoria.

The calx, therefore, or metallic earth of the regu
cobalt, is the sole cause of the blue color produced by
But as the quantity of regulus contained in cobalt is
able, therefore some zaffres furnish more blue than o
The heterogeneous, fixed matters contained in co
contribute, according to their quantity, not only t
greater or less intensity of the blue color, but also
lustre and beauty. For which reason those who m
facture zaffre from cobalt make frequent essays o
roasted ore, by mixing it with vitreous matters to di
the intensity and beauty of the blue color.

Good cobalt calcined would form too deep a blue
almost a black glass, if it were not previously
with a certain quantity of vitreous fritt. In the m
facture of zaffre, therefore, the calx of cobalt, the str
of which has been previously determined by Essays, is
with such a quantity of sand, or of powdered flint
quartz, that with the addition of some saline flux, a
blue glass may be formed.

The zaffre that is commonly sold, and which c
from Saxony, is a mixture of calx of cobalt with
vitrifiable earth, as we have said. It is of a grey c
as all calxes of cobalt are before vitrification. Some z
are dearer than others, according to the intensity o
color which they are capable of producing. Zaffre is
ployed in the manufacture of pottery and of porce
for painting the surface of the pieces of ware, upon w
it is applied together with some saline flux, previou

aking or glazing, that the same fire may also vitrify oloring material.

e blue of zaffre is the most solid and fixed of all the that can be employed in vitrification. It suffers hange from the most violent fire. It is successfully yed to give shades of blue to enamels, and to the l-glasses made in imitation of some opake and transpa- precious stones, as the lapis lazuli, the turquois, the e, and others of this kind. *See the articles* AZURE, LT, INK (SYMPATHETIC), *and* SMALT.

EOLITES. *(a)*

ZINC.

ZEOLITES. This name is given by Mr. Cronstedt to a lescribed by him in the *Transactions of the Academy of Sciences ckholm for the year* 1756, the peculiar properties of which nduced that mineralogist to consider it as forming a distinct of earths, called *zeolites*. The properties of this stone or f earths, are the following.

It is a little harder than the fluors, and calcareous spars. It e scratched by steel, from which it does not elicit sparks.

It may be easily melted by heat without addition, into a frothy slag, which not without great difficulty can be reduced solid and transparent. Crystallized zeolites, when melted, as borax does.

It may be dissolved in the fire more easily by mineral alkali by borax or by the fusible salt of urine.

It does not effervesce with the fusible salt of urine, as calca- stones do; nor with borax, as gypseous stones do.

It dissolves very slowly, and without effervescence, in acids, oil of vitriol, and spirit of nitre. When concentrated vi- acid is poured on powdered zeolites, a heat arises, and the er is changed into a gelatinous mass.

In the very moment of fusion it gives a phosphoric light.

olites has been found only in an indurated state. It is either, nsisting of particles of no determinate form; or, 2. *sparry*; or, *ystallized*.

e zeolites that consists of particles of no determinate form, ther *pure* and white; (or it is *mixed with silver and iron*; n latter kind is of a blue color, and is commonly called lapis i. *See* LAPIS LAZULI.

e *sparry zeolites* resembles calcareous spar, but is more e. This is of a light red, or orange color.

*ystallized zeolites*. Groupes of crystals of zeolites are found rm of white or yellow balls consisting of many pyramids the es of which unite in the center; or of white prisms with trun- l angles; or of white capillary crystals.

Zeolites

ZINC. Zinc is a ſemi-metal, of a brilliant
color, approaching to blue. It is the leaſt brittle o
ſemi-metals; and when well furniſhed with phlog
which may be affected by treating it with inflamm
matters in a cloſe veſſel, it poſſeſſes a ſemi-ductility
means of which it may be flattened into thin plates.

This property, joined to its hardneſs, which is
conſiderable, renders it incapable of being pulveriſed
the other ſemi-metals; therefore, when it is required
divided ſtate, it muſt be melted and granulated, or
like metals.

The ſpecific gravity of zinc is nearly the ſame as th
regulus of antimony; that is to ſay, it loſes in water a
a ſeventh part of its weight. *(c)*

This ſemi-metal is not eaſily calcined or covered
ruſt by the action of the air and of water: in this reſpe
reſembles tin. It is leſs fuſible than tin and lead,
does not melt till it is almoſt red-hot. When it only fu
the degree of heat neceſſary for its fuſion, its ſurfac
calcined and reduced to a grey calx, eaſily reducible,
thoſe of tin and other fuſible metallic ſubſtances. But wh
is expoſed to a heat approaching to a white-heat, it flar
and during this inflammation it exhibits a very beau
and ſtriking appearance. The flame of zinc is infin
more lively, more luminous, and more brilliant, than
flame of any other inflammable matter. It is of a dazz
white, and is ſo vivid as to be inſupportable to the fi
This flame cannot be attributed to any ſulphur w
might be ſuppoſed to remain united with the zinc,
we ſhall ſee that this ſemi-metal cannot be united
ſulphur; but merely to phlogiſton, which in zinc is
combuſtible. This ardent deflagration is a moſt ſen
proof of the preſence of this principle in metallic
ſtances.

Zeolites has in the fire nearly the ſame properties as boles b
See *Stockholm's Tranſ.* for the year 1755, and *Cronſtedt's M*
*ralogy*, §. 108.

*(b)* Zinc when broken appears of many flat, ſhining plate
facets, which are larger when ſlowly than when haſtily coo
When heated, it is very brittle. Like tin, it makes a crack
noiſe when it is bent.

*(c)* According to Muſchenbroek's Table of Specific Gravi
Indian zinc is to water as 7.2401 to 1: and zinc of Goſlar
7.215 to 1.

e deflagration of zinc is ſo violent, that the earth is ſemi-metal, although naturally very fixed, like of almoſt all metallic ſubſtances, is raiſed in form of ſmoke, which is condenſed, and floats in the air like flocks. Theſe are called *flowers of zinc*, and *philoſophi-ol.* *See* FLOWERS *of* ZINC.

nc being the moſt combuſtible of all metals, detonates violently than any other metal with nitre. From hiteneſs and brilliancy of the flame produced by this ation, it has been employed with very good effect as gredient in compoſitions for fire-works.

acids are capable of diſſolving zinc. Six parts of vitriolic acid diluted with an equal weight of water can e entirely, by help of gentle heat, one part of zinc. eutral ſalt reſulting from this ſolution is cryſtallizable; s called *white vitriol*, or *vitriol of zinc*. *See a deſcrip-the method in which this vitriol is made at Goſlar, at the* SMELTING *of* ORES.

nc has a ſtrong affinity with vitriolic acid. It appears e a ſtronger than any other metallic ſubſtance: for ans of this ſemi-metal the vitriols of copper and of may be decompoſed. It ſeparates theſe metals from triolic acid, to which it unites and forms a white . But what is remarkable, is, that notwithſtanding reat affinity of zinc with vitriolic acid, the vitriol of is decompoſed, and its acid ſeparated by leſs heat he martial vitriol, as Junker affirms in the firſt volume *Conſpectus Chymiæ*. If this experiment ſucceeds, as bly it does, we muſt refer the cauſe of it to the particular of the inflammable principle in zinc and in iron. All roperties of theſe two metallic ſubſtances ſhew that abound in phlogiſton, and therefore vitriolic acid with them preferably to any other. But, at the ſame this phlogiſton is in theſe metals much unfolded and y combined, which is undoubtedly the cauſe, that eutral ſalts which they form with the vitriolic acid e decompoſed by the action of fire. For the phlo- of theſe metals adhering but ſlightly to their earth, be more eaſily combined with the vitriolic acid, and onverting this acid into volatile vitriolic, or ſul-ous acid, may ſtill more facilitate its ſeparation.

t as the inflammable principle of zinc is more abundant, nore ſlightly engaged than that of iron, zinc ought nite with vitriolic acid preferably to iron, and the l of zinc ought to be decompoſed by fire more eaſily the vitriol of iron.

When white vitriol is diſtilled by violent heat, the ſame phenomena happen as when martial vit diſtilled. Towards the end of the diſtillation of vitriol, a vitriolic acid ariſes, dephlegmated, thoug ſulphureous. This acid, added to common conce vitriolic acid, produces as much heat as water woul done if added to the ſame concentrated acid.

Zinc may alſo be diſſolved in the nitrous and acids. But this latter acid does not touch a black which ſeparates from the ſemi-metal during its ſo M. Hellot, who has examined the phenomena of th tion as well as thoſe of the ſolutions of this ſem in the vitriolic and nitrous acids, has aſcertained th black matter is not mercury, and that it cannot reduced into a metallic ſubſtance. *(d)*

Zinc may be allayed or mixed with all metallic ſub excepting *biſmuth (e)*. If theſe two metals be melted to they will be found ſeparately at the bottom of the cr the zinc, being the lighter, lying above the biſmuth. allay of zinc with iron is effected difficultly; bu with copper ſucceeds well, and is much uſed, on of a ſingular property which zinc has of unitin copper in a conſiderable proportion, as, for inſtan part of zinc to four or three parts of copper, much diminution of the ductility of copper. Zin to copper renders this metal leſs ſubject to ruſt, an to it a yellow color reſembling that of gold. This ſo allayed with zinc is called *braſs* or *latten*. *See* BR

The color of braſs approaching to that of gold, duced chemiſts to ſearch for the means of commun to copper the true color of gold; and they have ſucceeded in the compoſitions or allays called *tombac lor*, *Pinchbeck*, and *Prince's metal*. Beccher had fai equal parts of copper and zinc mixed together gave to the touch-ſtone like that of the gold from the Stahl remarks that the proportion of zinc menti Beccher is too great, but does not determine wh proportion ought to be. Since that time, the due tion has been inveſtigated, and ſeveral fine imitat gold have been found. The Engliſh were the fi ſucceeded, and they called their invention *Prince'* or *Prince Rupert's metal*.

*(d)* Neuman ſays, that this black matter was ſeparate the ſolution of this ſemi-metal in vitriolic and in mari and that two or three days afterwards it was re-diſſolved.

*(e)* It cannot be allayed with the ſemi-metal called ni

e perfect imitations of gold have been lately made croix and Leblanc; each of whom produced a me- mixture, one of which excelled in ductility, and ner in color. But these artists have not revealed their es. M. Geoffroy has made with this view many ex- nts, the detail of which may be seen in the Memoirs Academy for the year 1725. It appears from these ments, that the remark made by Stahl, that an equal ty of zinc is too much, was very just, with regard to ctility of the allay, but that equal quantities pro- the finest color. We may nevertheless observe, that per requires a strong heat to keep it fused, and as s very volatile, these two substances cannot be mixed it loss, both of the copper, some of which is calcined, f the zinc, a part of which is burnt and dissipated nes. Hence it follows, that after the mixture is the proportion betwixt the two metals is not certain. some experiments which I have seen, I can scarcely suaded that a fine-colored mixture can be obtained, rticularly of a deep enough yellow, if as much zinc per actually remained. *(f)*

must also observe, that in order to have a fine-colored uctile metallic mixture of this kind, it is necessary, ling to Mr. Cramer, to use the purest zinc. The uthor shews the means of purifying it, and of ascer- g its purity. This method is founded on the re- ble property which zinc has of being incapable of g with sulphur *(g)*. Therefore, to purify this semi- from the allay of other metals, it is necessary to upon it, when melted in a large crucible, suet and

One part of zinc is said to be capable of destroying the duc- of a hundred parts of gold. An allay of equal parts of nd gold is very hard, white, capable of receiving a fine po- nd not subject to rust or tarnish: hence it is proposed by alouin as a good material for making specula of telescopes. gives hardness to tin, and is therefore added in some com- ns for making pewter.

Mr. Cramer says that zinc does not easily unite with sul- but that if it remains long in a moderate fire, and be co- over with sulphur at several times, and continually stirred poker, it will be at last changed into a very brittle, dark- d substance. I suspect that the iron of the poker contri- to this union of zinc with sulphur, for I have never been unite sulphur with pure zinc, when I stirred them with a o-pipe.

ſulphur alternately, and the latter in larger quan
the former. If the zinc is pure, the ſulphur burns
its ſurface; but if it is allayed, the ſulphur combine
other metals, and forms with them a kind of ſcoria w
be taken off. This alternate projection of ſuet an
upon zinc is continued till the ſulphur be burnt o
face of the melted zinc without forming any ſc
zinc thus purified, may be ſucceſsfully employed f
of braſs or metallic mixtures in imitation of gold.

The affinities of zinc are, according to Mr.
Table, in the following order: Copper, iron, fil
tin, and lead. This laſt is ſaid to be only partl
with zinc. Sulphur might be ſo placed in this
to ſhew its incapacity of uniting with zinc.

The chief uſe of zinc is as an ingredient in th
ſition of braſs. M. Malouin, who, in his Mem
Zinc, has mentioned ſeveral properties of this ſ
which he finds analogous to thoſe of tin, relates
Memoirs ſome experiments which he made with
in order to ſubſtitute zinc for tin, in the opera
iron plates, &c. called *tinning*. As all the propert
ſemi-metal are not yet diſcovered, it may perhaps
after found applicable to other uſes. *(b)*

*(b)* Some authors, as Wallerius and Cronſtedt,
filings of zinc are attracted by magnets. I have not b
obſerve this property.

Zinc unites more ſtrongly to acids than any other
even ſome earths. Mr. Pott ſays, that it precipitates
baſis from a ſolution of alum; and that zinc cannot be p
from aqua-fortis by crabs eyes. He alſo ſays, that
precipitated by volatile alkali, but that this precipitate
re-diſſolved.

The ſame author ſays, that zinc, by being conv
flowers, acquires an additional weight, equal to $\frac{1}{10}$th
ſemi-metal employed.

Mr. Malouin relates, that zinc being melted ſix time
fuſion continued 15 hours each time, it became more
hard, brittle, unfuſible, and uncalcinable. He ſays
color became grey after the ſecond fuſion, brown after
black after the fourth, blue like a ſlate after the fifth,
violet-color after the ſixth.

Concerning the ores and eſſay of ores of zinc, *ſee*
ZINC; and concerning the methods of extracting large
of this ſemi-metal from its ores, *ſee* SMELTING *of* C
PLATE II. *Fig.* 15, *and* 22, *with the explanations.*

FINIS.

N

S.

ere the beſt

*torts.*

pple.

FIG.

# EXPLANATION

OF THE

# PLATES.

## PLATE I.

1. A RETORT. *See* alſo *Fig.* 12. A. where the beſt form of a Retort is ſhewn.
   A, Its belly or bowl.
   B, Its neck.
2. Retorts of this form are called *Engliſh Retorts.*
3. A GLASS ALEMBIC.
   A, The cucurbit.
   B, The head.
   C, The gutter within the head.
   D, The beak.
4. A LONG-NECKED GLASS ALEMBIC.
   A, The body of the matraſs.
   B, The neck of the matraſs.
   C, The head of the alembic.
5. A GLASS ALEMBIC *conſiſting of one Piece.*
   A, The cucurbit.
   B, The head.
   C, The aperture in the head.
   D, Its ſtopple.
   E, The mouth of the cucurbit.
6. A PELICAN.
   A, The cucurbit.
   B, The head.
   C, The aperture in the head with its ſtopple.
   D, The two curved ſpouts.
7. A ROW *of* ALUDELS.

## EXPLANATION OF PLATE I.

FIG. 8. A COPPER ALEMBIC.

A, The body or cucurbit.
B, The neck.
C, The head.
D, The beak, nose, or spout.
E, The refrigeratory or cooler.
F, Its cock.
G, The receiver.

FIG. 9. A MUFFLE.

FIG. 10. *A perpendicular section of a* CUPPEL *or* T
The curve line represents the cavity that contains
metal. The plan or any horizontal section of a cupp
a circle.

FIG. 11. AN INGOT-MOULD, into the cavities of wl
melted metals are poured.

FIG. 12. AN APPARATUS *for* DISTILLING, by wl
the vapors that usually escape in the ordinary metho
distillation, are condensed by passing into water or s
other fluid. This apparatus was invented and described
by Mr. Peter Woulfe. *See the Phil. Trans. Vol.* I.VII.

A, A retort. Instead of this retort, in the distillatio
some substances, may be substituted an iron pot wit
stone-ware head, the neck of which is to be inserted
the receiver, as in the present Figure.

B, A receiver, with a neck, into which the neck of
retort is to be inserted; and a spout at its bottom, thro
which the distilled liquor passes into the bottle C;
an opening in the side at D, into which one end of a
bent at right angles is inserted. The other end of this
passes into a vessel H, open at both ends, the lo
opening of which is closed with a glass stopple. Thro
the upper mouth of the vessel H, one end of another tub
bent twice at right angles, passes, while the other end of
tube is inserted into a bottle F, and immersed in the wate
other fluid contained in that bottle. The crooked t
are fitted into the mouth of the vessel H by means of a c
in which are two semi-circular notches, through which
tubes pass, and by lute.

The tube which passes into the bottle F is fitted into
mouth of this bottle by means of a cork, in which is a se
circular notch. This mouth of the bottle F is not cl
with lute.

The vapor that is raised from the substance expose
heat in the retort passes into the receiver B, where pa
it is condensed, and flows into the bottle C, while the

paſſes through the tube at D, into the veſſel H. this veſſel, the vapor that ſtill remains uncondenſed through the crooked tube I, into the water con- in the bottle F, by which it is all condenſed except- me elaſtic air, which is extricated in almoſt all tions. This elaſtic air ariſes through the water, capes at the ſemi-circular notch of the cork in the of the veſſel, which is therefore not accurately cloſed .

noſt diſtillations a quantity of air is abſorbed at different luring the proceſs: and in this caſe the external air eſs on the liquor in the bottle F, and force it through be I into the veſſel H, from which it may be taken by g the ſtopple L.

uſe of the veſſel H is to receive the liquor that may s raiſed from the bottle F, and to prevent it from into the receiver B, and from thence into the C, where it might ſpoil the diſtilled liquor.

Woulfe, in the above-mentioned Philoſophical ctions, relates ſeveral experiments made with this tus, from which the utility of this method of con- vapors by making them paſs into water, or ſome luid ſuited to the nature of the liquor diſtilled, ap-

s, by diſtilling twelve pounds of ſal ammoniac with me and two gallons of water, he obtained eight and a quarter of volatile alkaline ſpirit ſufficiently to make eau de luce, which were collected in the joined to the receiver; and upon adding two other of water, he obtained ſeven pounds of weak volatile e ſpirit. The water contained in the bottle F, was ſix quarts, received an encreaſe of 2½ lb. in from the vapor condenſed in it; and from experi- made to compare the ſtrength of the alkali thus ſed by the water with that of the ſtrongeſt alkaline firſt obtained, and which we have ſaid was fit king eau de luce, it was found, that the ſtrength of rmer was to that of the latter as 140 to 76: hence antity ſaved by this apparatus was nearly equal to unds of volatile alkali ſufficiently ſtrong for making luce. Mr. Woulfe obſerved a ſingular difference t the alkaline liquor collected in the bottle joined receiver, and that which was condenſed in the bottle F, namely, that a conſiderable heat was

excited by mixing the latter alkaline ſpirit, but n
former with vitriolic acid.

Another experiment is related, of the diſtillati
twelve pounds Averdupoiſe of common ſalt with an
quantity of oil of vitriol diluted with 7 lb. of wate
this operation 9 lb. 5 ½ oz. of ſpirit of ſalt were co
in the bottle C, and 6 lb. 12 ½ oz. of the ſame ſpiri
condenſed in ſix quarts of water in the bottle F.
reſiduum weighed 18 lb. 6 oz. Hence in this ope
there was a loſs of eight ounces, or $\frac{1}{70}$th part of the
moſt of which probably was elaſtic air. The ſtren
the acid condenſed in the water was found, by exper
to be to the ſtrength of the acid collected in the bo
as 200 is to 109. Theſe vapors, condenſed in water
found to be more concentrated when the diſtillatio
conducted ſlowly than when it was haſtened. It ap
alſo, that the moſt concentrated portion of the acid
ſalt is the moſt volatile, and that its ſtrength was to
vitriolic acid (the ſpecific gravity of which was to
water as 24 to 13), as 44 ¼ to 31. Experiments alſo ſ
that this vapor of ſpirit of ſalt condenſed in wate
tained no vitriolic acid, although the ſpirit collected
bottle C did contain ſome of that acid.

The ſame ingenious chemiſt formed a *marine et*
applying the vapor of rectified ſpirit of wine to th
concentrated vapor of marine acid, and by condenſi
united vapors in ſpirit of wine. This he effected by
contrived apparatus. The necks of two retorts,
which contained the ſpirit of wine, and the other t
ſalt and vitriolic acid, from which the marine acid
be diſtilled, opened into one receiver, where the
met: from this receiver the vapors paſſed through
into ſpirit of wine, contained in a bottle; and thoſe
were not there condenſed paſſed through another tu
ſpirit of wine contained in a ſecond bottle. By a furthe
lation and cohobation, with ſlaked lime, of the ſeveral
collected in the receiver and in the ſpirit of wine in
the vapors were condenſed, a very ſubtle penetrating
was produced. Mr. Beaumé had tried to procure a
ether by uniting the vapors of the marine acid, and c
of wine; but he failed, becauſe he did not uſe an e
method of condenſing the vapors.

Mr. Woulfe did not find that much advantag
gained by this method of condenſing vapors in water,
diſtillation of the nitrous acid from nitre mixed with

E II.

e prevented

ion may be
the ſulphu-
ole; to the
which ſub-
ater; to the
he vapors of
and, laſtly,

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This figure
copied from
*Engliſh Edi-*

owing man-
quadrangular
h (*a a*, *b b*,)
iid (*b b*, *c c*),
at top ſeven
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bottom to it
three inches
aſh-hole. 3.
hes from the
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ch a manner,
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heſe muſt be
n-plate (*h h*),
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the ſpace be-
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ſide

5

excepting that thus the noxious fumes are prevented hurting the operators.

thinks his propoſed method of condenſation may be cable to the diſtillation of vitriolic acid, the ſulphu- fumes of which are difficultly condenſible; to the ication of phophorus, the vapor of both which ſub- es ought to be condenſed by means of water; to the ication or diſtillation of vitriolic ether, the vapors of h ought to be condenſed in ſpirit of wine; and, laſtly, any other diſtillations.

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## PLATE II.

IG 1. *An* ESSAY *or* CUPELLING FURNACE. This figure the following deſcription of this furnace are copied from *ner's Art of Aſſaying. See Dr. Mortimer's Engliſh Edi- p.* 75.

The aſſaying furnace is made in the following man- 1. Make with iron plates a hollow quadrangular n, eleven inches broad and nine inches high (*a a*, *b b*,) ng at top in a hollow quadrangular pyramid (*b b*, *c c*), inches high, terminating in an aperture at top ſeven es ſquare. This priſm muſt be cloſed at bottom with her iron plate, which ſerves as a baſis or bottom to it . 2. Near the bottom make a door (*e*) three inches , and five inches broad, that leads to the aſh-hole. 3. ve this door, and at the height of ſix inches from the , make another door (*f*), of the figure of a ſegment circle, four inches broad at its baſis, and three inches a half high in the middle. 4. Then faſten three iron s on the forepart of this furnace; let the firſt of them , eleven inches long and half an inch high, be faſten- o that its lower edge ſhall reſt againſt the bottom of the ace, with three or four rivets, and in ſuch a manner, there may be between the upper edge of the ſaid plate the ſide of the furnace a groove ſo wide, as that the s of the lower door (*k k*) may be put into it, and free- ove backwards and forwards therein: theſe muſt be of a thicker iron-plate. The ſecond iron-plate (*h h*), n inches long, three inches high, and perfectly paral- the foregoing plate, muſt be faſtened in the ſpace be- n the two doors, in ſuch manner, that both the upper the lower edge of it may form a hollow groove with the ſide

ſide of the furnace. One of theſe grooves, which is
ed downwards, ſerves to receive the upper edges o
ſliders that ſhut the lower door (No. 2). The other,
turns upwards, is to receive the inferior edges of the f
of the ſmall door above (No. 3). The third plate
which is like the firſt, muſt be rivetted cloſe above the
door, in ſuch manner, that it may form a groove tu
downwards, and contiguous to the upper edge of the
door (No. 3). 5. In order to ſhut both doors (No
3), you muſt adapt to each of them two ſliders ma
iron-plates, that may move within the above-ment
grooves (*k k*, *l l*); but the two ſliders belonging to the
door (No. 3.) muſt have each a hole near the top; th
one a ſmall hole one fifth part of an inch broad, an
inch and a half long (*m*); and the other a ſemi-cir
aperture, one inch high and two inches broad (*n*). Le
ſides, each ſlider have a handle, that they may be laid
of when they are to be moved. 6. Moreover, let
round holes, one inch broad, be bored in the furnace,
of which muſt be made in the fore-part of the furnace
two others in the back-part, all at the height of five i
from the bottom, but three inches and a half diſtant
each ſide, of the furnace; and, finally, a fifth hole (*p*
the height of one inch above the upper edge of the
door (*f*). 7. In ſhort, let the inſide of the furnac
armed with iron-hooks, jetting out half an inch, and a
three inches diſtant from each other, to faſten the lute
which the furnace is to be covered over within. 8.
then an iron, moveable, hollow, quadrangular pyramic
three inches high, be adapted to the upper aperture (*d*
the furnace, at the baſis ſeven inches broad, ending
wards in a hollow tube (*r*), three inches in diameter,
inches high, almoſt cylindrical, though ſomewhat co
gent at top. This prominent tube ſerves to ſupport a
nel or flue, which is almoſt cylindrical, hollow, ma
iron-plates, and two foot high, and which, when a
ſtrong fire is required, is put perpendicularly upon
ſhorter tube, in ſuch manner, that it enters cloſe in
one inch and a half, or two inches deep, and may aga
taken off at pleaſure, when there is no need of ſo ſtro
fire. But this pyramidal cover (*q*) muſt beſides have
handles (*s s*) adapted to it, that it may be laid hold of,
thus be taken away or put on again: and that this,
put on the aperture (*d*) of the furnace, may not be
thrown down, let an iron plate be rivetted to the righ

upper edge of the furnace (*c c*), and be turned down
vards the inside, so as to make a furrow open before
behind, into which the lateral edges of the cover may
er and be fastened, and at pleasure be moved backwards
forwards, whenever it must be put on, or moved. 9.
a square ledge, made of a thick iron-plate, be fastened
op of the upper edge of the lower door (*e*); this is de-
ed to support the grate and the lute: but it must be
le of two pieces, that it may be easily introduced into
cavity of the furnace. Thus you will have an assay-
n, which must afterwards be covered over on the inside
h lute. This you are to do as follows:

That the fire may be better confined, and that the
may not be destroyed by growing red-hot, the whole
de of the furnace must be covered over with lute, one
er or one finger and a half thick. The lute fit for this
nade of a mass of clay mixed with sand, and moistened
h three or four times as much of ox-blood diluted with
er *. But before you cover the inside of your furnace
h this lute, you must first put within the furnace small
bars, equal in length to the diameter of the oven,

The best lute, and easiest to be had at London, is a sort of
called Windsor loam, which must be mixt pretty stiff, and
led into the inside of the furnace, first wetted with water; and
n the clay begins to dry, it must be beat down close to the
s with a wooden mallet; then the unevenness and cracks
d up with fresh clay somewhat moister, so as to be made
oth and even with a trowel, and then left to dry gently; and
ny cracks happen, they must again be filled up. *Note of Dr.*
*timer.*

tourbridge clay, tobacco-pipe clay, or any other pure clay that
ot fusible by fire, may be used for this purpose. But as fresh
shrinks and cracks very much in drying, it ought to be mixed
an equal quantity or more of coarse white sand, or of burnt
grossly powdered. Thus one part of Stourbridge clay, one part
oarse white sand, and one part of Stourbridge bricks grossly
dered, being well mixed together, make a good lute for lining
inner surfaces of furnaces. To prevent the iron plates of the
aces more effectually from calcination, their inner surfaces
ht to be covered with a coating of charcoal-powder formed into
ass or paste, with as much fresh clay and water as are sufficient
that purpose; and when this coating is dry, the above-men-
ed lute may be applied. During the drying the lute ought to
laily beat with a mallet, that the spaces left by the shrinking
he clay may be closed, and the lute be rendered more compact.

quadrangular,

quadranglar, prismatical, half an inch thick, having
extremities supported by a square iron ledge, and t
fourths of an inch distant from each other; and you
fasten them so, that their flat sides may be oblique
regard to the transverse section of the furnace, and tha
two opposite angles may look one upwards and the
downwards; the bars must not be laid flat, but edge-v
by which situation you hinder the ashes of the fuel of th
from being detained too long between the interstices o
said iron-bars, and from making an obstruction that v
oppose the free draught of the air. The furnace being
covered over with lute, and dried up by a gentle he
at last fit for docimastical operations, and especiall
such as must be performed in the assay-oven.

If then an operation is to be made in the furnace hit
described, you must let through the four lower holes
described, of the furnace (*o o*) placed before and be
and directly opposite to each other, two iron-bars one
thick, and long enough that their extremities on ever
may jut out of the holes a small matter. These se
support the muffle and its bottom (*See* Plate I. FIG
You then introduce the muffle through the upper ape
of the furnace (*d*), and place it upon the above-desc
iron-bars, in such manner, that the open fore-side
be contiguous to the inward border of the upper door
The fuel of the fire is introduced through the top o
furnace (*d*); the cover of which, on this account,
be moveable and not very heavy (*q*). The best fuel fo
fire is charcoal made of the hardest wood, especial
beech, broken into small pieces of the bigness of an
wherewith the muffle must be covered over some i
high. We then reject larger bits of coals, because
cannot fall through the narrow interstices, betwee
sides of the muffle and those of the furnace, and cann
course sufficiently surround the circumference of the m
Whence it happens, that there are on every side place
of fuel, and the fire is either not strong enough or unc
But if, on the contrary, you use coals too small, t
great part fall immediately through the interstices o
grate into the ash-hole; and the tenderest particles of
turn too soon into *ashes*, and by increasing the he
ashes, obstruct the free draught of the air, which i
greatly requisite.

" A perfect management of the fire is most comm
necessary in the performing of operations in this fur
the

refore the reader muſt give attention to what follows: If door of the aſh-hole (*e*) is quite open; and the ſliders of upper door (*f*) drawn towards each other, ſo as to touch another in the middle of the door; and if, beſides, cover (*q*), and the funnel adapted to its tube (*r*), is on the top (*q*) of the furnace, the fire will be then in the heſt degree poſſible; though, in the mean time, it is hard-ver neceſſary to put the funnel on, except in a very cold ſon: but if, after having diſpoſed the furnace in the nner juſt deſcribed, you put red burning coals into the n upper door (*f*) of it, the fire is ſtill more increaſed reby: however, this artifice is never, or very ſeldom, eſſary. When you ſhut the upper door with only that er that has a narrow oblong hole in it (*m*), then the t becomes a little leſs; but it diminiſhes ſtill more when ſhut the door with the other ſlider that has in it the i-circular hole (*n*), which is larger than that of the firſt er: nay, the heat again is leſs when you take away the nel put at top of the cover: finally, the door of the -hole being either in part or totally ſhut, the heat is ſtill iniſhed, becauſe the draught of the air, ſo neceſſary to ite the fire, is thereby hindered: but if, beſides all theſe, likewiſe open the upper door quite, then the cold air, hing into the muffle, cools the bodies put under it, that to be changed, to a degree never required in any ope-ion, and ſuch as will entirely hinder the boiling of lead. during the operation, the fire begins to decay, or to w unequal, it is a ſign that there are places void of ls between the ſides of the furnace and thoſe of the ffle; therefore, in this caſe, you muſt ſtir your coals on ry ſide with an iron-rod, which is to be introduced ough the upper hole (*p*) of the furnace, that they may together, and thus act in a proper manner and equally.

However, you are to obſerve concerning the regimen the fire juſt deſcribed, that though the *apparatus* is made h all the exactneſs mentioned, nevertheleſs the effect s not always anſwer it. The cauſe of which difference moſt commonly its origin in the various diſpoſitions of air; for as every fire is more excited by coals in pro-tion as the air, more condenſed, and more quickly tated, ſtrikes them more violently (which the effect of lows plainly ſhews); it thence appears, that in warm wet weathers, when the atmoſphere is light, the fire ſt be leſs efficacious in furnaces; that likewiſe when ſeve-furnaces, ſituated near each other, are burning at the ſame time,

time, the fire is in part suffocated; because the ambie is thereby rendered more rare and lighter. The same is produced by the sun, especially in summer-time, w shines upon the place where the furnace is situated. atmosphere, on the contrary, being heavier in co weather, excites a very great fire.

"The heat of the fire acts the stronger upon the l to be changed, as the muffle put in the furnace is le the said muffle has more and larger segments cut out as the sides of this muffle are thinner; in short, as are more vessels placed in the hinder part of the m and on the contrary. In this case, when many conditions requisite for the exciting of fire are wa then indeed the artificer, with all his skill, will har able to excite the fire to a sufficient degree, in order t form operations well, in common assay-ovens, even t he uses bellows, and puts coals into the upper door furnace. For this reason, I have put the grate almost inches below the muffle, left the air, rushing throug ash-hole, should cool the bottom of the muffle, happens in common assay-ovens; and again, tha smaller coals, almost already consumed, and the ashes more easily fall through the interstices of the grate, a larger coals still fit to keep up the fire be retained. Fi I have added the above-mentioned funnel, that the bl of the fire being, by means of it, increased as much a sible, this might at last be carried to the requisite d for the fire may always be diminished, but not alw increased at pleasure, without the assistance of a prop *paratus*."

Fig. 2. This figure represents a furnace call Athanor. *See* Athanor. This figure and the fo ing description are copied from *Cramer*'s *Art of A* "This furnace is used for the distillation of acid for calcinations, cementations, &c. As these oper require a long and constant fire, an athanor is usefu cause it can contain as much fresh fuel as will keep fire for many hours together, and admits of a differe accurate, and most constant regimen of the fire.

"Let then, 1st, a small square hollow tower *(a* be constructed of such *stones*, [or of bricks made of *bridge clay*, or *Windsor loam*,] as may resist the fire; sides of it be six inches thick, and forming a square within, of ten inches on each side *(b b b b)*. The of it is determined according as it is to keep up the fire

w

hout any addition of new fuel: five or six feet are moſt
mmonly ſufficient. 2. At the bottom of this tower
ke an opening (*c*), ſix inches broad, and as many inches
h; hang to it an iron door, being on every ſide one inch
ader than the opening, and ſuch as may ſhut it very
ſe: for which purpoſe the external edge of this opening
ſt be excavated all round in ſuch a manner, that it may
n a groove one inch broad, into which the edges of the
r may be received. 3. At the diſtance of ten inches
m the bottom of the tower, put a grate (*d*), made of
matical, quadrangular iron-bars, one inch thick, and
ee quarters of an inch diſtant from each other: let alſo
h of theſe iron bars be ſo ſituated with regard of the
ver, that the two oppoſite acute edges of each may look
pendicularly, one downward, the other upwards, that,
this means, the aſhes may eaſily fall into the aſh-hole.
Make above this grate an opening circular at top (*e*)
inches high, ſeven inches broad, that may, as well as
aſh-hole (No. 2), be opened and ſhut with an iron-door.
Adapt to the top of the tower an iron cover (*f*), exceed-
the aperture of the tower all around two inches, and
ving a handle, wherewith it may be eaſily taken away,
l put on again. Thus you are to make the furnace
led in Latin *furnus primarius*. 6. Then cut out in any
e of the tower, for inſtance, in the left, an oblong ſquare
rture, going up obliquely towards the outſide (*g g*),
r inches and a half high, ten inches broad, having its
ward inferior edge one inch and a half, or two inches
ove the grate (*d*); that by the intervening of this hole,
cavity of this tower may communicate with another im-
diately to be deſcribed. 7. Nearly over-againſt the
ne ſide of the tower, make a cavity with ſtones, whoſe
erior part muſt be a hollow priſm (*h, h, h, h,*) ſix
ches high, twelve inches broad, ending at top in a ſemi-
lindrical arch (*i, i,*) deſcribed by a *radius* of ſix inches;
t by this means, the height of the whole cavity may be
elve inches in the middle. Let this anterior cavity be
ally open, though, when requiſite, it is to be ſhut very
ſe with an iron plate (*k, k,*) whoſe inward ſurface is to be
nſtructed in the ſame manner as is preſcribed for the ſliding
or of the melting-furnace, (FIG. 4.) and then luted two
ches thick within. Moreover, let there be in the middle
this plate, a round hole, four or five inches in diameter,
d let the circumference of this hole have an iron cylin-
cal border made to it, and prominent within; that by
means

means of it, the lining of lute within may be suppo
and kept from falling down easily. Let a notch one
broad, and two inches deep, be made in the outward ci
of the aperture of this cavity, to receive the extremi
the plate that shuts the aperture. The hole of this
either is shut with a stopple, or serves to pass the nec
the retort through. This plate likewise is fastened with
bolts *(n, n,)*, to be put horizontally with iron h
*(o, o, o, o,)* driven into the wall near the edge of the apertu
that one bolt may fasten the upper part of the plate, an
other the lower. 8. It is moreover proper, that the sq
aperture *(g, g,)* through which the fire enters from
tower into the cavity hitherto described (No. 7.), ma
shut and opened at pleasure with an iron slider: for if th
not done, an excessive fire, employed sometimes by an
experienced hand, cannot be so easily checked. For
purpose, let a slit half an inch broad, and eleven in
long, be left in the wall that constitutes the upper
of the cavity (No. 7.), and is contiguous to the to
so that it may exceed the length of the square a
ture, *(g, g,)* a small matter on every side, and r
before and behind into the small groove, going down a
the perpendicular sides of the said aperture, *(g, g,)*
retain the iron-slider to be put into it to keep it ste
However, let this iron-slider be six lines thick, el
inches broad, and five inches high; and let a coupl
small iron-chains *(p, p,)* be fastened on each side o
upper edge, wherewith the slider may be lifted up anc
down again. Therefore let a couple of strong iron-nail
drove into the contiguous wall of the tower, perpendicu
over those places in which the said small chains are fast
to the iron-slider, that any of the links of the chains
be suspended on them at pleasure. Moreover, let the u
edge of the slit above described be entirely shut up
stones and cement, leaving only two small holes thro
which the small chains may be passed. On the left of
cavity (No. 7.), and at the distance of eight inches f
the bottom of it, let a square *(q, q, q, q,)* chimney or fu
be erected with *bricks*, three inches and a half in the cl
four foot high, and a small matter convergent upwards
that the diameter of it at top may be three inches.
funnel must be contrived to be shut closely with an i
slider, having a handle to it *(r, r,)*, which slider must m
freely between a double iron square frame fastened in
walls of the funnel, at such a height from the he

ll ſeem convenient to any artificer. 10. Below this ey let a ſquare aperture be made, like the foregoing 6. *g*, *g*,), leading obliquely up to the bottom of another rical cavity, (*u*, *u*, *u*, *u*,) which is eight inches deſcribed by a *radius* of ſix inches, open at top, and converging inwardly into a border one inch thick, x lines broad, deſigned to ſupport an iron-pot. Like-cut in the anterior wall of this cavity, and at the part of its mouth, a ſegment two inches and a half five inches broad, and ſtooping forward (*v*, *v*,) to e the neck of the retort. 11. To this cavity (No. 10.) s an iron-pot (*w*, *w*,) eleven inches broad, and nine inches deep, which muſt be encompaſſed with n ring (*x*, *x*,) one inch broad, and faſtened at the e of one inch and a half from the upper end of the Let a ſegment *(y)* be likewiſe cut off the upper edge pot, which ſegment muſt be four inches and a half and five inches broad: the iron-ring juſt deſcribed e bent all round the edges of this ſegment. 12. Over- the aperture (*t*, *t*,) which communicates from the vity (No. 7.) into the ſecond (No. 10.), let another perture (*z*) be made, two inches diſtant from the of the ſecond cavity (No. 10.) perfectly like the ng (*g*, *g*, *t*, *t*,) and communicating obliquely up- with a third cavity (1, 1, 1, 1,), like and equal to cond cylindrical cavity *(u, u, u, u,)*; that the fire ſs from the latter into the former. 13. In the hinder f the wall which makes the aperture juſt men- (*z*), let a chimney like the foregoing *(q, q, q, q,)*, the ſame height (2, 2, 2, 2,), be erected, which may with a ſlider like that (3). 14. Finally, on the left the third cavity let an aperture be made in the ſame (4), and like the foregoing ones *(g g t t z)*; more however from the bottom of the cavity, without a at the other extremity, and communicating only he cavity of the third chimney (5, 5, 5,), which e erected in the ſame manner as the two foregoing *q*, *q*, *q*, 2, 2, 2, 2,). Thus you will have a furnace oper for a great many operations.

Ve are now to ſpeak of the uſe of the *athanor* juſt ed; and chiefly to mention, to what operations each parts ſerve in particular, and then how the fire may uſt be governed in it. 1. You muſt put at the arched door *(e)* of the tower a ſemi-cylindrical muffle inches long, which muſt be introduced through

the door: which for this reason must be of the same height and breadth as that door, three quarters of an inch thick, and open behind, being shut there by the hinder part of the athanor, as far as which it must reach. For this purpose, a *tile* must be set upon the grate *(d)* to support the muffle. Let also this muffle have small pieces cut out near its basis, as common assay-muffles. You may put under this muffle your cement pots, or such bodies as must be calcined with a long and violent fire; which can be done without a muffle, though not so neatly. 2. In the first chamber *(h, h, h, h, i, i,)* you may make the most violent distillations with an open fire: for retorts or large vessels are introduced into it, after you have taken away the door *(k, k, k,)*, and are put either upon the hearth itself of this chamber, or upon a particular support of stone. But you must place these vessels in such manner, that their necks may easily pass through the hole of the door, when put on again: for which purpose, they chuse a support sometimes higher, sometimes lower, according to the different heights of the vessels. When afterwards, the door is put on again, and fastened with both its bolts *(n, n,)*, you must close with lute all the chinks which lie open about the neck of the vessel, and between the edges of the door and the entrance of the chamber. Then you apply to the neck of the vessel a cylindrical segment, ten or more inches long: by means of which the heat and the boiling vapors coming forth are gradually diminished; lest the recipient, which is always chosen a glass vessel, should split. The recipient, which must be united with the other orifice of the said segment, is supported either by the pavement, or by a certain kind of trivet, the construction of which is such, that it may be set lower or higher by means of three screws. 3. In this same chamber, instead of distillations, you may also make cementations, calcination, &c. in which case the round hole of the iron-plate may be shut and again opened with a stopple, that one may view the inside. 4. The second and third cavities *(u, u, u, u, 1, 1, 1, 1,)* serve chiefly to such operations as are made in baths [or beds] of *sand*, *ashes*, or *filings*. For instance, you put into each of these cavities a pot, *(v, v,)*, and you stop with thin *lute* or with *sand*, which must previously be moistened, the slip between the iron-ring *(x, x,)* and the border of the cavity, upon which this ring rests. 5. Besides, you may also make in these two cavities, distillations by a reverberating fire, as well as in the first: only the fire is less violent

t in these, though sufficient to extract aqua fortis. hen take out the iron-pot (*v*, *v*,) and inverting it, it it upon the mouth of the chamber; so that the f the pot, being the depth of one inch and a half above on-ring (*x*, *x*,) wherewith this pot is surrounded, e received within the mouth of the cavity, and so he segment cut in the pot *(y)* may, together with gment cut out from the side of the cavity (*v*, *v*,) hole to let the neck of the vessel through. 6. All *paratus* being thus ready, you first introduce through o of the tower *(b, b, b, b,)* a few burning coals; and pon them some of the unkindled fuel of the fire; that vity of the tower may, according as it is thought ry, be filled either entirely or only in part. Then l speed you put upon it the iron-cover *(f)*, and strew rder of this on the outside with *sand* or *ashes*, which ress gently with your hands: for if you should t this point, all the fuel contained in the tower would dled, and may endanger setting the house on fire.

shall here annex a few general rules concerning the n of the fire in this furnace: for it is hardly necess- o explain all particulars, since practice will easily hem to such as shall be ever so little acquainted with istry. The fire may be made very strong in the first er, (*h, h, h, h, i, i,*) when the door of the ash-hole (*c*), he funnel (*q, q, q, q,*) of the chamber is quite open, hen the iron-slider suspended with chains (6. *p, p,*) ot hinder the fire from passing freely from the tower is cavity. But the closer the funnel is shut, together he door of the ash-hole, the more the violence of the iminishes: and this will be soon effected, if the iron- suspended with chains is let down in part: for the ontained in the tower burns at least as high as the between the lower edge of the iron-slider and the *(d)*. Observe besides, in those operations wherein und hole of the door is stopt with a plug, that when ongest fire is required, this hole must not be kept pen; because the air rushing violently through it, ools the bodies put into the cavity. The operations mentioned may be performed in the second and third er, in, and at the same time, and with the same fire, y are in the first chamber; for the fire penetrates from rst cavity into the second, and increases when the (2, 2, 2, 2,) erected on it is opened: but before you do the funnel of the first cavity must be shut as much

as that of the ſecond is opened. By the ſame means, you may hinder the fire, which ſerves for the operations made in the two firſt cavities, from going out through the funnels, and you force it out, on the contrary, through the third cavity and through its funnel (5, 5, 5,); that it may alſo act upon the bodies placed in that cavity. For the more the funnel erected upon the third cavity is open, the more one, or even both funnels of the other two cavities muſt be cloſed: thence it is plain, that you cannot kindle the ſtrongeſt fire in the third cavity, unleſs there be one equally ſtrong in the other two; and that, on the contrary, the heat in the third cavity may be rendered leſs, by cloſing its funnel; though it be violent in the others. The ſame is true of the ſecond cavity, with regard to the firſt. Finally, you cannot make the ſtrongeſt fire under the muffle placed within the upper door *(e)* of the tower, unleſs you have an equal fire in the firſt cavity, which fire may conſequently be increaſed, by ſhutting the door quite againſt the muffle *(e)*, and diminiſhed by opening it; there being mean while an equal heat in the firſt chamber, and in the following ones. The reſt will eaſily be learned by practice."

FIG. 3. A REVERBERATING FURNACE.

*a*, The aſh-hole door.
*b*, The fire-place door.
*c*, *c*, *c*, *c*, Regiſters.
*d*, The dome or reverberatory.
*e*, The conical funnel.
*f*, The retort in the furnace.
*g*, The receiver.
*h*, *h*, Iron bars to ſuſtain the retort.

FIG. 4, 5, 6, 7, *and* 8, repreſent a MELTING FURNACE. Theſe figures and the following deſcription of this furnace are copied from *Cramer's Art of Aſſaying Metals.*

The melting furnace is made of iron-plates, the inner ſurfaces of which are covered with lute. The cavity of it may be formed according to an elliptical mould. 1ſt, Make an hollow ellipſis, the focus's 12 inches aſunder, and the ordinate 5 inches long; cut it off in both its focus's, that it may aſſume the figure *(Fig* 4.*)*. 2dly, Then make in this hollow body, and near its lower aperture, four holes, eight lines in diameter, and directly oppoſite (*c*, *c*,). 3dly, Then faſten two flat iron-rings *(d)*, almoſt one inch and a half broad, at both the upper and the lower inward edge of this oval cavity; and fill the inſide of it with ſmall iron-hooks, jutting out about ſix lines, and three

r inches diſtant from each other. Theſe, together the rings juſt mentioned, ſerve to faſten the lute. will the body of the furnace be made: only you muſt the outſide two iron-handles (*e*, *e*,) to be rivetted on de of it, that it may be taken hold of and moved.

Then make the cover of the furnace, which may ned like the part cut off from the ellipſis (See *Fig.* 5,). is have an opening *(b)* made in it, four inches high, ches broad at bottom, and four inches at the top; apt to this an iron door hung on hinges to ſhut it and having at the inſide a border faſtened to it, ing exactly to the circumference of the door, and as ent inwardly as the thickneſs of the lute to be ap- it requires: for the ſame purpoſe, let ſmall iron- be faſtened to the inſide of the door, which is inter- by the ſaid border. And leſt this cover ſhould be within by the force of fire, you muſt cover the of it over with the ſame lute mentioned before for ay-oven: therefore it muſt be likewiſe furniſhed with and iron-hooks to faſten the lute; as was ſaid before, we ſpoke of the body of this furnace. Beſides this, uſt faſten two iron-handles *(Fig.* 5. *c*, *c*,) on the outſide cover. Then a round hole muſt be made in the top being three inches in diameter, prolonged into a tube *(d)* almoſt cylindrical, and a few inches high, which the iron-funnel deſcribed may, in caſe of ty, be put after the manner mentioned in the ſame where we ſpoke of the aſſay-oven. 5thly, After this, ing of both the body and cover of the furnace within le in the ſame manner above-deſcribed. Moreover, uſt make for this furnace two moveable bottoms, ne to receive the aſhes, and admit the air; the other e for reductions. The firſt is made with an iron- formed into a hollow cylinder, open at top, and ſhut at bottom with an orbicular iron-plate, as baſis, five inches high, and of ſuch a diameter, t it may receive the inferior orifice of the body of nace *(Fig.* 4.) the depth of half an inch *(See Fig.* 6.): re let an iron-ring (*c*), half an inch broad, be d on the inſide of the ſaid bottom, and at the diſtance an inch from its upper border, to ſupport the body furnace put into it. Again, let this bottom have a door, four inches high, and as many inches broad, ay be ſhut cloſely with a door hung on hinges, that you means of it increaſe or diminiſh the draught of the

 air,

air, and thus govern the fire at pleasure. Then, on th left side of this door, and at about half the height of thi bottom part, let a round hole *(d)* be made, one inch and a half in diameter, to admit the pipe of the bellows when need requires. Next to this, let another bottom part be made of the same matter and figure as the foregoing: let it be likewise of the same diameter, but two inches higher, so that it may be of the height of seven inches. Likewise let it have round it a like iron-ring below its upper border, to support the body of the furnace to be received in it. But let a hole two or three inches broad, and one inch high (*Fig* 7. *c.*), be cut out just below the ring in the side of this bottom part; then let another round hole be made in the left side of this first hole, fit to admit the pipe of the bellows *(d)*. Further, let another round hole like the foregoing (*e*) be made on the right, and at the distance of one inch from the bottom: then let the whole inside of this bottom part (the part above the ring excepted) be overlaid with lute, and a bed be made at the bottom, of a figure like that represented by the line *(f, g, h,)*. The matter of which this is made is common lute pulverised, passed through a sieve, and mixed with such a quantity of dust of charcoal, sifted in the same manner, so that the mixture being moistened and pressed down, may at least be lightly coherent. Of this matter pressed on the bottom of the bottom part a bed is made, like a segment of a sphere, having in the middle a small cavity somewhat lower, and made extremely smooth, after the manner mentioned before when we spoke of large ash-vessels or tests.

This furnace is chiefly fit for fusions, which may be made in it with and without vessels. When you are to melt with a vessel, put the body of the furnace (*Fig.* 4.) upon the first bottom (*Fig.* 6.), that has a door to it to open on hinges; introduce two iron-bars through the holes of the furnace (*Fig.* 4. *c, c,*); put upon them the iron-grate, which you are to introduce through the upper mouth of the furnace: then put in the middle of this grate a *brick* or square *tile*, very smooth every where, warmed, and perfectly dry: otherwise, the vessels put upon it, especially the large ones, are easily split by the moist vapors coming out of it in the operations. Let the height and width of this *stone* be a small matter broader and higher than the bottom of the crucible or pot to be set upon it; for if it were less high, the bottom of the vessel could not be sufficiently warmed; and if it were less broad, the vessel might easily fall from it: then

ut upon this *tile* the veſſel containing the matter to be , and ſurround it immediately with coals on every which muſt be ranged according to the method pre- l before, in our deſcription of the aſſay-furnace: ou govern the fire, by opening and ſhutting the door aſh-hole *(Fig.* 6 *b)*: you excite it by putting the *(Fig.* 5.) upon the body of the furnace; and if, , you put a funnel upon the cylindrical mouth *(d)* cover, the melting fire becomes ſtill more violent: you moreover introduce the bellows through the f the bottom part *(Fig.* 6. *d)*; and the joint of the e with the bottom part, and the door of the aſh-hole, it can be ſhut very cloſe, being exactly ſtopt with ute [*or Windſor loam*], the fire thus excited by the f the bellows is carried to the higheſt degree, and far es that which may be made in a Smith's forge. Another age of this method is, that the veſſels are not ſo eaſily , becauſe the blowing of the bellows cannot affect immediately, and becauſe a fire perfectly equal is ex- on every ſide. One may eaſily examine with this *tus*, how *ſtones* are affected by the violence of the ly. Now, if you have a mind to perform any opera- ithout a veſſel, and with a naked fire; for inſtance, t and reduce the *calxes* or *ſcorias of copper*, *tin*, *lead*, *n*, or the ores of theſe metals; the body of the furnace e put upon the other pedeſtal, having a bed in it .). However, you muſt, before this, open with a the oblong hole (*c*), and the round one *(d)* of this part, which are ſtopped with the lute ſticking to ſide: then you apply at the round hole *(d)* on the le of the bellows, in ſuch manner that the nozzle of ng directed obliquely downwards, may blow ſtrongly the bed *(f, g, h,)*: by this means, all the aſhes that to the bed are blown away, and the ſtrength of the termined to ſuch a degree, that all the melted bodies all into the ſaid bed remain in their ſtate of fuſion; ere it otherwiſe, the melted bodies would immedi- wax cold, and adhere in grains to the bed, whereas ught to have melted into one *regulus*. The oblong n the fore-part of this bottom-part (*c*) ſerves to er, by means of a poker, whether the matter in the e melted or not: it ſerves likewiſe to take away gh it whatever might ſtop the bellows, and in ſome o take away the *ſcoria*: then you put firſt coals into urnace one ſpan high, and blow them well with the

 bellows,

bellows, to make them burn, that the bed may be very before the matter to be melted is put into it; for if th not previously done, the melted mass seldom runs in *regulus*, but remains dispersed among the *scorias*, w soon grow hard. The bed being well heated, and coals added to the fire, put into it such quantity of matter to be melted as cannot hinder the fire from b carried to the requisite degree; which cannot be d mined otherwise than by experience: again, put coals, and upon them another quantity of the matter melted; they may be, like *strata*, one upon another: if the mass, once melted, could not long sustain the stre of the fire, or if you had a mind to melt a greater qua of matter than what can be contained in the bed, you open the round lower hole (*Fig.* 7. *e.*), that you make a channel passing from that hole through the and reaching to the small cavity at the bottom of the (*g*): to this hole, at the outside, apply an earthen dish the bed within, or any other proper recipient, surrou with burning coals, into which the matter melted run from the bed through the hole (*Fig.* 7. *e.*), may be colle as is represented by *Fig.* 8.

Fig. 9. A transverse section of a Furnace in w Sulphur is obtained *by distillation* from pyrites. In furnace are placed ten or twelve tubes, one of whic represented in this section (7), lying across the w breadth of the furnace. These tubes are open at both e At the larger end the mineral, from which the sulp is to be distilled, is to be introduced; and then the ope is to be closed with an earthen stopper. The smaller opens into a cast-iron receiver (8), which receives sulphur that is distilled or eliquated. To prevent crude mineral from passing into the receiver, a star piece of baked earth is placed in the neck or smaller of the tube, along with the sulphur. Each furnace tains ten or twelve such tubes. The length of the w furnace is therefore evidently much greater than its brea The tubes are about four feet long, somewhat of a con form, six or eight inches wide at their larger end, and t quarters of an inch at their smaller end.

1. The walls of the long sides of the furnace.
2. The ash-hole.
3. The grate made of bricks.
4. The fire-place.

5.

## EXPLANATION OF PLATE II.

. The paſſage for the flame to the upper part of the furnace.

. The two walls of the long ſides of the furnace which ſupport the tubes.

. A tube placed acroſs the furnace.

. A ſquare caſt-iron receiver.

. Two holes in the roof of the furnace through which the ſmoke eſcapes. There are generally ten or twelve ſuch holes in different parts of the roof, ſome of which are occaſionally cloſed. *See a further deſcription of this furnace, and of the operation of extracting ſulphur, at the article* SMELTING *of* ORES.

G. 10. This figure repreſents a tranſverſe ſection of a NACE *for* PURIFYING SULPHUR *by* DISTILLATION. MELTING *of* ORES.

. The foundation of the wall ſunk under ground.

. The ſide-wall.

. The back-wall.

. The aſh-hole.

. The grate.

. The fire-place.

. Two holes through which the ſmoke eſcapes.

. The inner chamber of the furnace.

. An iron cucurbit or pot.

. A neck made of earthen-ware.

. The veſſel called the fore-runner.

. A receiver.

. A banquette or ſtep raiſed to ſupport the fore-runner. In this furnace, which is of an oblong ſhape, generally five or ſix ſuch ſetts of diſtilling veſſels are placed on each ſide.

G. 11. Repreſents a *quantity of ore piled up to be roaſted.*

. Two ſides or faces of the pile. All the ſides of it are covered with ſmall ore.

. The upper part of the pile, where holes or cavities are ſeen in which the ſulphur of the ore is collected.

. An opening where part of the pile has fallen down, and in which the ſulphur is ſeen dropping down.

. A plank to keep off the wind. *See* SMELTING *of* ORES.

IG. 12. *A Section of the above Pile.*

. The wood to make the fire.

. Some charcoal for the kindling of the fire.

. A channel formed by a wooden tube or pipe.

4. The

4. The large lumps of ore.
5. Small ore.
6. Finer ore, or duſt of ore.
7. The ſubſtance called *vitriol*, that is, a half ore powdered.

FIG. 13. Repreſents a longitudinal ſection of the NACE *at* RAMMELSBERG. *See a deſcription of this at the article* SMELTING *of* ORES *of* SILVER.

1. Foundation of the maſonry in the ground.
2. A part of the back-wall.
3. The tuyere.
4. Channels to carry off moiſture.
5. The covering ſtone of theſe channels.
6. A bed of ſcoria.
7. The caſe or caſſe made of bricks.
8. A bed of clay.
9. A bed of ſifted ore and ſubſtance called vitrio
10. The charcoal which is thrown into the caſſe p to the filling of the furnace with ore and fuel
11. A mixture of fat earth and charcoal powde which the furnace is prepared or lined.
12. The hearth, with the trace.
13. The ſeat of the zinc.
14. The chemiſe.
15. The wall of one ſide of the furnace.
16. The middle wall of the furnace.

FIG. 14. Repreſents a longitudinal ſection of a R BERATORY FURNACE uſed in the *ſmelting of ores. deſcription of this furnace at the article* SMELTING *of* C COPPER.

1. The maſonry.
2. The aſh-hole.
3. A channel for the evaporation of the moiſture.
4. The grate.
5. The fire-place.
6. The inner part of the furnace.
7. A baſon formed of ſand.
8. The cavity where the melted metal is.
9. A hole through which the ſcoria is to be rem
10. The paſſage for the flame and ſmoke, or th part of the chimney, which is to be carried height of about thirty feet.
11. A hole in the roof, through which the ore is into the furnace. This furnace is eighte

long, twelve feet broad, and nine feet and a half high.

IG. 15. Represents the upper plan of the FURNACE, of ch FIG. 14. is a section.

1. The outer wall.
2. The draught-hole communicating with the ash-hole.
3. The door through which fossil coal is thrown into the fire-place.
4. The place where an opening is made to let the melted metal flow out of the furnace.
5. An opening through which the scoria is drawn off.
6. The bason made of sand where the metal lies.
7. The fire-place with an iron-grate.
8. A small wall between the fire-place and the area or bason, over which the flame passes.

IG. 16. Represents the plan of a REFINING FURNACE refining silver or copper. *See* REFINING *and* SMELTING ORES *of* SILVER.

1. The pillars and walls of the furnace.
2. The bason of bricks, about eight feet in diameter.
3. The base of the vault of the furnace.
4. The great flame-hole, through which the metal to be refined is introduced.
5. Two holes for the bellows.
6. The hole through which the litharge runs off.
7. The grate on which the fire is made.
8. The door of the fire-place through which the wood and faggots used as fuel are introduced.
9. A bason for the reception of the refined copper, when that metal is refined in this kind of furnace.
10. A passage which is to be occasionally opened to let the copper flow out.

IG. 17. Represents a *longitudinal section* of the refining nace, of which FIG. 16. is a plan.

1. The masonry of the pillars and walls surrounding the furnace.
2. The channels for carrying off the moisture.
3. Other small channels which join in the middle of the bason.
4. The bason made of bricks.
5. A bed of ashes.
6. The hollow or bason in which the metal is melted and refined.
7. The great flame-hole.

8. The

8. The two openings for the entry of the tuyeres bellows.
9. The vault or dome of the furnace.
10. The fire-place.
11. The grate.
12. The draught-hole.
13. A hole in the vault, which, being opened, ſer cool the furnace.

FIG. 18. Repreſents a ſection of an AIR MEL FURNACE.

1. The maſonry.
2. The grate.
3. The aſh-hole.
4. The aſh-hole door.
5. The fire-place and fuel.
6. A crucible or pot containing the metal to be r ſtanding upon a brick ſupport, and covered tile.
7. A horizontal flue or paſſage through which th paſſes to the chimney (8). In this horizont a brick door opens laterally oppoſite to the tef By this means the ſame furnace ſerves botl melting furnace for melting metals in cru and alſo for the operation of teſting or cupel
8. The chimney.
9. The mouth of the furnace through which thrown. This mouth is covered with a ſtonc iron-plate.
10. A teſt ſurrounded by ſand. The flame of t ſtrikes upon the metal contained in the cavity teſt.
11. An aperture through which the flame paſſes i horizontal flue. The area of this aperture i fourteen to twenty-two ſquare inches.

The dimenſions of this furnace may be ſuited quantities of metal to be melted. General area of the plan of the fire-place is from 64 ſquare inches, that is, the length of each ſide area is from 8 to 12 inches.

This complex furnace is uſeful to refiners of gc ſilver: but where the teſting part of the furnac wanted, as in furnaces for melting braſs or ſte horizontal flue (7) need not have any lateral o or door. The length alſo of this flue may be

ed, and its width made equal only to that of the aperture (11).

FIG. 19. This figure represents a vertical transverse section of a REVERBERATORY FURNACE invented by Schlutter for the process called *eliquation*, by which silver is separated from copper. *See the article* ELIQUATION.

1. The masonry surrounding the furnace, excepting the front (9).
2. Two walls inclined to each other, covered with the two iron plates (7, 7,) that support the metal (8) to be eliquated.
3. The way through which the lead and silver eliquated from the metal (8) flows towards a bason made for its reception without the furnace.
4. The inside of the furnace.
5. The ash-hole.
6. The grate and fire-place, from which the flame passes towards the plates of metal (8), and escapes at a chimney in the end of the furnace most remote from the door of the fire-place.
7. Two plates of iron.
8. A cylindrical piece of metal composed of the copper containing silver, and of a sufficient quantity of lead to cause the eliquation. The silver and lead thus eliquated from the copper, fall down into the cavity (3), and flow into a bason on the outside of the furnace. In this furnace ten or twelve such cakes or cylindrical pieces of metal are placed parallel to each other.
9. The front of the furnace, through which the pieces of metal are introduced. This front is closed with an iron door lined with clay, the length of which is equal to the length of the internal part of the furnace. This door may be raised by means of a chain and pulley, when the pieces of metal are to be introduced.

FIG. 20. Represents a vertical section of a FURNACE *for* SMELTING *of* ORES *of* IRON.

*a, a, b, b,* The height of the furnace above the level of the ground.

*b, b, c, c,* The part of the furnace below the level of the ground.

*d, d,* Shew the height where the great mass of masonry terminates, and the smaller mass and thinner walls called *battles* begin.

*d, a, a, d,*

*d, a, a, d,* One of these walls called *battles.*

*e,* The mouth or upper opening of the furnace.

*f, f,* A platform.

*g, g,* Sections of the smaller mass of masonry.

*i, i,* The beginning of the etalage. The space *i, i, e,* is sometimes called the *charge.*

*k, k,* The end of the etalage, and the beginning of the work.

*i, k,* 1, and *i, k,* 2, Are sections of the etalage.

*e,* The bottom of the work.

*m,* The place where the melted metal and scoria flow out of the furnace. The scoria flows over the dame (*n*), and the metal flows at the bottom of the dame, and on one side of it, through passages made occasionally in the bank of sand and clay, with which this lower part of the front of the furnace is closed.

*n,* The dame.

*o,* A workman opening a passage for the scoria over the dame, by means of a bar of iron.

*p, b,* A section of the arched space or embrasure, in the front of the furnace, under which workmen stand.

Q. The vault under the furnace.

R, R, Beams of wood to strengthen the walls of the furnace.

X, A workman throwing fuel and ore into the furnace.

Fig. 21. Represents a *plan of the above furnace* taken at a level with the tuyere.

*k,* The work.

*m, s,* The front of the furnace.

*n, n,* The bellows.

*o,* The tuyere.

*p, q,* The outer walls of the furnace.

*r, r,* Two iron bars or pokers placed upon the dame (*s*).

*m,* The opening through which the metal flows.

*m, t,* The channel, and moulds made in a bed of sand, for the reception of the iron, when it flows out of the furnace.

*x, x,* The inner walls of the furnace.

Fig. 22. Represents a vertical section of a reverberatory furnace, used for the obtaining of Zinc from its ores. The construction of this furnace resembles nearly that commonly used for making of glass. It is a reverberatory vaulted furnace, the plan of which is circular. The hearth of this furnace is supported by arched pillars. On this hearth, six large pots, each of which is about four feet high,

high, and contains ſome hundreds of pounds of ore of zinc, and of charcoal, or other inflammable matter, are placed in a circular row. Two of theſe pots (2, 2,) are repreſented in this ſection. A circular hole (4) is left in the hearth for the paſſage of the flame from the fire-place into the reverberatory, from which it eſcapes at a hole in the arch (9). In the head of each of theſe pots there is a hole for the introduction of the ore, which hole is ſtopped, during the operation, with a ſtopple of baked earth (1, 1,); and alſo there is a hole in the bottom, correſponding with a hole on that part of the hearth on which the pot is placed. Through each of theſe latter holes is inſerted an iron tube (3, 3,), which is cloſely luted to the contiguous parts of the pot and hearth of the furnace. The pots are to be filled with the mixture of ore and coal, in the following manner: The ſtopple (1) of the mouth of a pot is to be removed, and into this mouth, one end of an iron tube or funnel is to be inſerted, through a hole (8) in the vault immediately above the pot, while the other end of the tube or funnel remains without the furnace. Through this tube the mixture of ore and coal is introduced into the pot; then the tube is removed, the ſtopple is fitted and luted with freſh clay to the mouth of the pot, and the hole in the vault (8) is to be covered with a lid.

When the ore thus introduced is ſufficiently heated, the zinc is revived or reduced by the inflammable matter mixed with it, riſes in the ſtate of vapor, which finding no other vent, paſſes down the tube (3). The lower end of this tube (3) being in contact with the external air is ſufficiently cold to condenſe this vapor of zinc, and the zinc accordingly flows out of the lower end of the tube in the ſtate of a melted metal, and falls or drops into a veſſel (7) containing water, where it becomes ſolid. Thus zinc is obtained from its ores by the kind of diſtillation called *per deſcenſum*. When the diſtillation is finiſhed, which is generally in three or four days, according to the heat applied, the nature of the ore, and other circumſtances, the tube (3) is removed, the reſiduum is thruſt out of the hole in the bottom of the pot by means of an iron bar or poker introduced through the opening of the vault (8) and the upper mouth of the pot. When the pot is emptied of the exhauſted ore, the tube (3) is to be replaced, freſh ore and coal are to be introduced in the manner above-mentioned, and the operation is to be repeated,

peated, without cooling the furnace or removing the veſſels.

This ſection is not taken from an exact menſuration, and therefore the proportions of the ſeveral parts are not accurately ſhewn. Nevertheleſs, as this method of obtaining zinc has not before been publiſhed, the preſent figure may help to explain this ſingular proceſs.

# ADDITIONS

TO THE

# ICTIONARY

OF

# CHEMISTRY.

BY

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LONDON:

TED FOR T. CADELL, AND P. ELMSLEY,
IN THE STRAND.

M.DCC.LXXIX.

# CONTENTS.

CID (VITRIOLIC). When vitriolic acid is well concentrated, it is capable of congealing by a degree of cold expressed by r 14° of *Reamur*'s thermometer. For the knowledge of this :rty we are indebted to the zeal which the *Duke d'Ayen* has for iences. He has lately communicated to the academy a set of iments and observations, no less important than curious, for n he availed himself of the extraordinary cold at the end of *ary*, 1776. He exposed to this cold different matters, and, among , vitriolic acid in different degrees of concentration. Some very ntrated vitriolic acid, exposed in a window, in a porcelain cup, g the night of the 27th of *January*, was entirely frozen in 7 hours. At the same time were exposed to the same cold, and in me manner, mixtures consisting of one part of the same acid, to f which two parts, and to another four parts of water had been , without any appearance of congelation at the end of 30 hours. e *Duke d'Ayen* relates in a letter which accompanies his me- that having diluted one part of the acid with eight parts of , this mixture could not be frozen with the same degree of cold h had congealed the pure concentrated acid. But what must ar the most extraordinary to persons to whom the phenomena emistry are not familar, is, that this same concentrated vitriolic which was entirely frozen in eight hours, thawed spontane- in the space of thirty hours, although the cold rather encreas- an diminished towards the latter part of the time. The cause is singular effect did not escape the *Duke d'Ayen*, who was sen- that as the concentrated vitriolic acid, when exposed to air, ts moisture; and as a degree of heat is always excited by this mixing with water, and also, as he had discovered that this acid ndered less capable of freezing by being diluted with water, causes must concur to destroy the congelation.

though the mixture of even a considerable quantity of water vitriolic acid obstructs the congelation of this acid, (water being ble of freezing with a much less degree of cold than the pure entrated acid) there must be some limit of dilution, at which the tity of water will be so great as to determine the mixture to e at even a less cold than the concentrated acid does; and ac- ngly the *Duke d'Ayen* found from an experiment, that some olic acid which did not freeze by a cold of ten or twelve de- , when its specific gravity was to that of distilled water, as o 96, began to freeze at the same degree of cold, when the was so much diluted, that its specific gravity became to that of r, as 104¼, or even as 103¾ to 96.

ARSENIC. Mr. *Navier*, Physician at Chalons, has lately published his researches into the remedies against metallic poisons, and especially arsenic. Being convinced from experience, that liver of sulphur, martial liver of sulphur, and also other solutions of iron in acids or in alkalis, can be readily decomposed by arsenic, even in the humid way; and that in these decompositions the arsenic unites with the sulphur or with the iron, he proposes to employ these substances, and even ink, when the others are not at hand, as antidotes to arsenic. These ideas must be approved by every person who understands chemistry, for since experience proves that arsenic unites in the humid way to the sulphur of the hepar, and to the iron of the martial solutions, it follows, that it ought to lose more or less of its causticity, in proportion to the intimacy of union which it contracts with these matters.

BLACK-LEAD; Called also, *Molybdena*, *Plumbago*. This matter, which is found in some mines, was not known till lately, but by the use that is made of it. It is commonly employed as a black crayon or pencil, and as a covering to the surface of utensils made of iron, in order to preserve them from rust, and to give them a good appearance. It is also mixed in a large proportion with clay, to form a composition for making the crucibles, which are called *Crucibles of Passau*, or *Black-lead crucibles*, and which are capable of sustaining violent heat. As no metal can be obtained from it, so as to produce profit in the smelting of it, metallurgists had entirely neglected to examine it.

Mr. *Pott* is the first chemist who has given any attention to this matter. He has published a dissertation on it. Although Mr. *Pott* is more engaged in this dissertation in discussing the sentiments of authors concerning it, and in shewing its uses, than in making an accurate analysis of it, the result, however, of the few experiments which he made is, that it contains no lead nor any other metal but iron. It is composed, according to this chemist, of a very refractory talky matter, and of a little vitriolic acid. The iron which black-lead contains, was partly indicated in Mr. *Pott*'s experiments, by the action of acids, which dissolved some of the contained iron, but not the whole of it, and by sublimation with sal ammoniac, by which martial flowers were produced. He observed also that the smoothness or unctuosity of black-lead, is not destroyed by acids, nor even by great heat, which seems to shew that this property proceeds rather from the scaly and smooth form of its particles, than from any matter which can be called properly greasy, although we shall hereafter shew that bleak-lead contains a good deal of phlogiston.

We are indebted for the most extensive and most satisfactory researches on this substance to M. *de L.* who has lately communicated them to the academy of sciences in a very good memoir on this subject, and he has been pleased to give me leave to communicate them before the publication of that memoir.

Black

Black-lead being exposed to a very violent fire in a crucible during two hours, was not observed by M. *de L.* to be sensibly diminished in weight: But having put some powder of black-lead on the bottom of a muffle heated white, he observed upon its surface an undulating motion, which continued till all the mica was decomposed or evaporated, and after it had been exposed to the fire while this undulation lasted, he found that nothing remained but a reddish-brown powder, which was attracted by a magnet, the certain indication that iron is contained in this mineral. But the most remarkable part of this experiment was the loss of weight which was sustained by torrefying this matter, in other respects so refractory; which loss Mess. *Pott* and *Quist* had before observed, and which was found by *M. de Lisle* to be so considerable, that of the soft kind of black-lead ninety parts out of a hundred were lost, and of the hard kind eighty-eight parts out of a hundred. So considerable a loss, which does only take place in circumstances necessary to combustion, seems to indicate the existence of a much greater quantity of combustible matter in black-lead than could have been suspected.

The residuums of these torrefactions yielded, by reduction, iron, in the proportion of two pounds four ounces of this metal to a hundred weight of soft black-lead, and of three pounds four ounces of iron to a hundred weight of the hard kind of this mineral. The iron proceeding from the soft kind was strongly attracted by a magnet, but the iron of the harder kind was not very sensible to the action of the magnet. This difference gives occasion to suspect, that notwithstanding the long torrefaction, the iron of the hard black-lead was not perfectly freed from sulphur, for nothing but sulphur can prevent iron from being attracted by the magnet.

I have remarked at the end of the article on *Ores*, that if we would know them very well, we must not be contented, as we have hitherto generally been, with submitting them to the action of fire in crucibles, but that it was very essential to collect their volatile parts in close vessels, by distilling them with and without intermediate substances. Several chemists, particularly M. *Sage*, have begun to follow this good method, which has already procured some important knowledge.

We find a new instance of the benefit of using this method in the memoir of *M. de L.* He exposed black-lead singly to the action of fire in close vessels, and distilled it in a retort which he kept red-hot during several hours, having previously put into the receiver some liquid fixed alkali, as M. *Sage* has practised in several of his analyses, and although he observed that this mineral did not lose any sensible weight by the distillation, yet the alkali was found to have formed cubic crystals; which circumstance induced him to

believe that ſome volatile acid had eſcaped from the black-lead, which acid uniting with the alkali, had occaſioned it to cryſtallize.

If the nature of ſalts could be determined by the form of the cryſtals, and if ſea-ſalt only aſſumed in its cryſtallization the cubical ſhape, this experiment would prove the exiſtence of the marine acid in black-lead: But the form of cryſtals is a deceitful mark, and not ſufficiently certain to aſcertain the nature of a ſalt without other concurrent proofs. Accordingly *M. de L.* not depending on this circumſtance, made other trials. He found that this ſalt precipitated ſilver from its ſolution in nitrous acid. But the compleat reduction of this precipitate by the ſole action of fire, proved that the acid in queſtion was not the marine, ſince this latter acid forms a luna cornea, which not only cannot be reduced without addition, and merely by heat, but cannot be reduced without ſome difficulty even by addition of intermediate ſubſtances. *M. de L.* ſuſpects that this acid of black-lead is the ſame as that of the ſpathoſe ores. Moſt of theſe ores, being treated by the ſame proceſs, exhibit the ſame phenomenon. But it is now known that this acid is the gas, known by the name of *fixed air*, or *mephytic gas*, which has no property in common with marine acid.

As it is very poſſible, that if we proceed to examine minerals more accurately than has been done, we ſhall find ſeveral which yield volatile ſubſtances, and even gaſes incapable of being fixed by alkalies, ſuch as *inflammable gas*, it follows, that the method of putting liquid fixed alkali into receivers is defective, and may lead to error, and that it is neceſſary to employ for this purpoſe the pneumato-chemical apparatuſes, which are adapted to the purpoſe of receiving and meaſuring the quantity of the gas expelled.

M. *de L.* expoſed black-lead to the action of ſeveral intermediate and diſſolving ſubſtances. He diſtilled two parts of vitriolic acid with one part of black-lead, and he obſerved, that the receiver was filled with white vapours, and a volatile ſulphureous acid, which continued to ſmoke even ſome days afterwards, when the bottle containing it was uncorked. This operation being repeated four times ſucceſſively, and the ſame acid being cohobated always upon the ſame black-lead, the acid at length became of a beautiful green colour, and by evaporation yielded firſt an ochery precipitate, as ſolutions of martial vitriol do, then a foliated and ſhining ſelenites, and laſtly cryſtals of alum.

The moſt remarkable circumſtance is, that notwithſtanding ſo many cohobations of vitriolic acid, the remaining black-lead was ſtill black and unctuous.

Nitre mixed in equal parts with this mineral, and expoſed to fire in an open veſſel, detonated; but the reſiduum nevertheleſs retained its black colour. When the ſame mixture was diſtilled in a retort, vapours of nitrous acid were produced; but when the bottom

bottom of the retort began to be red-hot, a detonation happened, which burst the vessels.

Lastly a mixture of equal parts of black-lead, and sal ammoniac, being sublimed, yielded flowers of sal ammoniac, evidently martial, of a lively yellow colour, the solution of which formed an ink when mixed with an infusion of galls. But when this sublimation was repeated upon the same black-lead, the colour of the flowers became fainter each time, and at length they were white, as M. *Pott* also had observed. But M. *de L.* mentions two circumstances which M. *Pott* has not observed. The first is, that the black-lead from which the sal ammoniac rose white, was not altered in colour nor in texture by the operation: and the second is, that the bottom of the glass vessel which had been used in these operations, had acquired very evident rainbow colours.

It seems to be well proved from the experiments of M. *Pott*, and still better by those of M. *de L.* that the greatest part or basis of black-lead is a micaceous talky matter, the earth of which being of an argillaceous nature, forms alum, with vitriolic acid, according to M. *Sage*'s observation; that this talky matter is so intimately combined with a certain quantity of ferruginous and phlogistic matters, which perhaps are nothing else than iron itself, as M. *de L.* judiciously observes, that neither combustion, nor the most powerful agents can deprive it entirely of these matters; and lastly, that in this mineral a volatile substance also exists, which seems to be acid, but of which the nature and quantity is not yet perfectly ascertained, and requires new researches of the kind which I have mentioned above.

## BLOOD.

THE analysis of blood was but little advanced at the time of the publication of the first edition of the Dictionary of Chemistry, and I therefore confined myself to wishes that it might be further prosecuted. These wishes have been since fulfilled beyond my expectations by M. *Rouelle* and M. *Bucquet*. The former has published his experiments in the *Journal de Medicine for* 1773 *and* 1776, and the latter in a memoir presented to the Academy of Sciences, not yet printed.

Before the researches of M. *Rouelle*, some authors, particularly *Haller* and *De Haen*, had observed that saline matters existed in the blood. *De Haen* particularly had deduced the presence of an alkali from the observation that water in which coagulated blood was washed was alkaline, and that dried blood effervesced with acids. M. *Rouelle* undertook to determine the kind and the proportion of this alkali, and whether it was in a combined or disengaged state.

 Having

Having obſerved that not only the ſerum of the blood of men and quadrupeds, but alſo the waters collected in different kinds of dropſies, have the property of being coagulated by moſt acids, by heat of boiling water, as the white of an egg is, of being miſcible with water, of acquiring a conſiſtence, and clarifying liquors like the other animal lymphatic fluids, and of changing the colour of ſyrup of violets to green as ſenſibly as water in which an alkali had been diſſolved; and having convinced himſelf from experiment, that the water diſtilled from the blood in a water-bath does not, while recent, in any degree alter the colour of ſyrup of violets, has thence juſtly concluded, that the property of making the ſyrup green is not owing to the alkaline quality of the ſerum of blood, nor to a volatile alkali contained therein, as ſome authors had thought, but to a diſengaged fixed alkali. His proofs are, that after a diſtillation of blood in a water-bath, the dry brittle matter, more or leſs coloured, and reſembling glue, (from which however it is different in this reſpect, that it is not eaſily ſoluble in water) contains really a fixed marine alkali, uncombined, which cryſtallizes in form of a ſaline effervescence, and which may be collected from the ſurface of this matter after it has been kept in a glaſs jar, covered only with paper, during a year, or a leſs ſpace of time, while this matter ſoftens and ceaſes to be brittle, by means of the moiſture which it receives from the air.

To this proof, ſufficiently convincing of itſelf, M. *Rouelle* adds ſeveral experiments. "If (ſays he) five or ſix pounds of ſerum of "blood, or of the water of dropſies, be diluted in twice as much "diſtilled water, to which, from ſix gros to an ounce of common "vitriolic acid has been previouſly added, if theſe be well mixed "together, and the mixture firſt dried in a water-bath, then re-"peatedly waſhed with boiling water, and if the lotions or water "thus employed, (which are acidulous) be ſaturated with chalk, "ſo that the ſuperabundant vitriolic acid may be engaged, the li-"quor, after filtration and evaporation in a water-bath, will yield "a true Glauber's ſalt." To prevent the objection that might be made from a ſuppoſition that the vitriolic acid might unite with the marine alkali, even if it were in a combined ſtate in the ſerum, M. *Rouelle* made an experiment in which he ſubſtituted diſtilled vinegar in place of vitriolic acid, and he obtained fine cryſtals of an acetous ſalt with baſis of marine alkali.

The remarkable exiſtence of a diſengaged marine alkali in the ſerum of blood, and other analogous liquors, is not the only diſcovery that has been lately made. The preſence of iron in this liquor is another no leſs important diſcovery. This metal has long ago been obſerved in vegetable aſhes. Some philoſophers have conſidered it as the cauſe of the colour of flowers. Its exiſtence has even been ſuſpected in animals, and the red colour of

blood,

blood has been attributed to it. But the first person who made a continued research into this subject is M. *Menghini*, who has proved that not only the blood contains much iron, especially in its red part, but also that martial preparations taken internally, pass in great measure into the blood, in which it produces, and by the analysis of which it may be again traced. The detail of these researches may be found in the second volume of the *Bolognian Memoirs*. To the experiments of M. *Menghini*, which are very satisfactory, M. *Rouelle* has added still more precision, and has published further observations on the saline matter contained in the blood, as may be seen in the *Journal de Medicine*, *July*, 1776. According to this able chemist, "the blood of healthy men being dried, burnt "and calcined to ashes, contains fixed mineral alkali; some sea-"salt, a small quantity of febrifugal salt, an animal or calcareous "earth, some iron, and lastly coal. The quantities of the fixed "alkali, and of the neutral salts, were found to be in the propor-"tion of 28 or 29 parts of the fixed alkail, to 16 or 17 parts of "the neutral salts. When the lotions or lixivia of the ashes of "blood are evaporated at different times, sea-salt is first obtained, "then febrifugal salt, and lastly fixed alkali.

"The ashes which remain after these lotions, are composed of a "little animal earth, of coal, and of a considerable quantity of "iron. The animal earth is nearly one-tenth of the whole; and "the quantity of coal is not very considerable, but varies accord-"ing to the degree of calcination.

"When these ashes are treated with pure marine acid, the earth "may be separated from the iron, as the acid unites with the earth "in preference to the metal. The iron then remains mixed with "a little coal, which is not readily separated from it.

"The iron obtained in this experiment is of a fine colour of "martial crocus, although it is attractable by a magnet, and if any "portion should not be attractable, this quality may be given to it "by soaking it in oil of olives, and making it slightly red-hot in a "retort or covered and luted crucible. The iron thus obtained "from blood, is soluble in all acids, and presents the same pheno-"mena as filings of iron dissolved in acids. Thus when vitriolic "and marine acids are employed, the vapours are equally inflam-"mable, and when vitriolic acid is used, a true martial vitriol is "obtained."

M. *Rouelle* has subjected to the same experiments the blood of several quadrupeds, with the same result, but with different quantities and proportions, not only among the different species of animals but also among different individuals of the same species, which differences must proceed from the nourishment or state of health which each animal happened to possess. The saline and ferruginous sub-

ſtances above-mentioned, although they appear to be contained habitually in blood, are nevertheleſs in ſome meaſure foreign to it, and ought not to be conſidered among the eſſential conſtituent parts of this fluid, which conſiſts almoſt entirely of a coagulable, lymphatic, animal matter. In a little time after it has been drawn from the veſſels of a healthy animal, it becomes, by reſt and cold, coagulated, and has a gelatinous appearance. But in time a yellowiſh liquor ſeparates from this coagulum, which appears to be the moſt watery part of the blood and is called *Serum*. This liquor readily mixes with water, and when it is dried in a water-bath, as M. *Rouelle* has done, it aſſumes the appearance and properties of an animal jelly or glue, with this difference nevertheleſs, that it is more difficultly rediſſolved in water than the pure glues, and that it is capable of being coagulated by the heat of boiling water, as the white of eggs and other lymphatic animal liquors are, ſo that it appears at once to partake of the nature of the gelatinous and of the lymphatic part of animals.

After the ſerum is thus ſpontaneouſly ſeparated from the coagulum, this latter ſubſtance may be further ſeparated into two very diſtinct parts by merely waſhing it repeatedly with water. The water carries off with it the red part which is very ſoluble; and the reſiduum, which is entirely white, is a concrete matter, inſoluble in water, and ſomewhat elaſtic. This matter is called the *fibrous part of the blood*. Of all the ſubſtances which circulate in animal bodies in a liquid ſtate, this appears the moſt diſpoſed to become ſolid, ſince it coagulates even in the cold, and in ſuch a manner that it cannot be any more diſſolved in water, ſo that it may be conſidered as more concreſcible than pure animal lymph.

M. *Bucquet* has principally examined theſe three parts of blood. According to this excellent chemiſt, the coagulation of the ſerous or lymphatic part of the blood is not cauſed by deſiccation or by the loſs of its watery part; but is ſolely the effect of heat.

The water obtained from it by diſtillation in a water-bath, as well as that obtained from other animal matters, although at firſt it be inſipid, and does not occaſion any alteration on ſyrup of violets, is not however pure; for it contains ſome animal matters. The proof of this is that at the end of a certain time, this diſtilled water ſhews ſigns of putridity, of a diſengaged volatile alkali, and renders ſyrup of violets green. M. *Rouelle* has alſo made the ſame obſervation. This ſerum being dried in a water-bath and diſtilled in a retort, yields, as ſoon as it is hot, ſome volatile alkaline ſpirit, a large quantity of ſolid volatile alkali, ſome fetid oil, the greateſt part of which is heavy and falls to the bottom of the alkaline ſpirit. The coal remaining in the retort is very light and ſpongy, and fills entirely

entirely the cavity of the veſſel. It contains much ſea-ſalt, and fixed marine alkali, which may be ſeparated by waſhing with water.

This coal thus lixivated is not eaſily reduced to aſhes. For this purpoſe it muſt be kept ſeveral hours under a muffle, by which means it becomes a grey aſh, like that of vegetables. This aſh when it is produced from a ſerum perfectly free from any mixture with the red part of the blood, contains but infinitely little iron.

This animal liquor mixes with cold water in all its proportions, and if it be thrown into boiling water, one part of it coagulates and another part unites with the water, but is not completely diſſolved; for the water becomes and remains milky and cannot be cleared by ſeveral filtrations through paper. When it is made to boil, it ſwells and froths; a pellicle is formed on its ſurface, like that on milk, and the addition of acids or of ſpirit of wine coagulates the particles which render the liquor turbid.

The ſerum of blood is extremely diſpoſed to become putrid; for M. *Bucquet* having expoſed ſome to air, it became putrid in ſo little time, that he could not determine whether it previouſly became acid.

When weak acids are mixed with ſerum, it is thereby coagulated; and when the remaining part of the liquor is ſeparated by filtration, neutral ſalts may be obtained by evaporation, which ſalts are formed of the acid employed in uniting with the marine alkali of the ſerum. The coagulated matter remaining upon the filter, being repeatedly waſhed, dryed and diſtilled in a naked fire, yields the ſame products as the ſame lymphatic ſerum which had not been mixed with acids. The coal remaining in the retort contains much marine alkali. It is proved by theſe experiments, that, if a part of this alkali exiſts in this liquor in a pure and diſengaged ſtate, there is alſo another part which appears to be combined, and which does not unite to theſe acids, and which cannot be carried off by the plentiful waſhing.

The concentrated nitrous acid diſſolves the ſerum after coagulating it. This ſolution is accompanied with much effervescence, and the diſſolved matter may be precipitated by addition of water.

Alkalis do not coagulate the lymphatic ſerous part of the blood; and the cauſtic volatile alkali even diſſolves it after it has been coagulated by other means. The compound which reſults from this ſolution by cauſtic volatile alkali cannot be decompoſed but by the action of an acid.

The neutral ſalts with alkaline or earthy baſes do not occaſion any alteration in the ſerum. But almoſt all the metallic ſalts form with it a conſiderable precipitate.

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We have already ſaid, that the ſerous part of the blood, even that part which can unite with water, is coagulable by ſpirit of wine. And it is well worth notice, that the ſerum thus coagulated by ſpirit of wine may be re-diſſolved in water, but that the coagulum by means of acids cannot be thus diſſolved.

The fibrous part of the blood, that is to ſay, that which forms the coagulum ſpontaneouſly by reſt and cold, after it has been deprived of all the red particles by waſhing in water, yields by diſtillation in a water-bath nothing but an inſipid phlegm, which at firſt is not alkaline, but which becomes alkaline when it has been kept ſome time. M. *Bucquet* obſerves that a very ſmall degree of heat hardens remarkably this fibrous part of the blood, even before it loſes its moiſture. It acquires at the ſame time a dirty grey colour, and ſhrinks as parchment does when expoſed to the ſame heat. This part of blood, being dried and diſtilled in a retort, yields nearly the ſame products as the ſerum does. But the coal that remains is more heavy and compact. It contains no ſaline matter, having been waſhed before its diſtillation. It may be reduced to aſhes more eaſily than the coal remaining after the diſtillation of ſerum, and its aſhes, which became perfectly white, contain neither ſaline nor ferruginous matter.

Other experiments of M. *Bucquet* teach us that this fibrous part is not ſoluble in boiling water, which on the contrary, hardens it, and at the ſame time, gives it a grey colour. It is not ſoluble by ſpirit of wine, nor by oils, nor by the yolk of an egg, nor by alkalies, nor even by cauſtic alkali, which we have ſaid diſſolves the coagulum of the ſerum. But all acids, even vinegar, eaſily diſſolve this matter. It may be ſeparated from its ſolution in acid by water, and ſtill better by alkalis. Theſe are remarkable properties and are analogous to thoſe of the glutinous animal matter of flour, and of cheeſe.

The red part of the blood ſeparates ſpontaneouſly from the ſcum, and, as we have ſaid, may be eaſily ſeparated from the fibrous part by waſhing with water, in which it is perfectly ſoluble: the water in which this red part of the blood is diſſolved becomes of a deep red, and the matter diſſolved differs little, as Meſſrs. *Rouelle* and *Bucquet* obſerve, from ſerum. Like ſerum, it is coagulable by heat, by acids, and by ſpirit of wine; it is ſoluble by volatile alkali; and it yields the ſame products by diſtillation; its coal is equally light and charged with common ſalt and mineral alkali; but it is with difficulty reducible to aſhes, and theſe aſhes, which are of a brown red, like a martial crocus, owe their colour to the iron which they contain in very great quantity.

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From these interesting experiments it appears that all the iron which is obtained in the analysis of blood, proceeds principally, if not solely from the red part; and they confirm the opinion of those who attribute the red colour of blood to this metal.

An observation in the practice of medicine, which is found to accord with this idea, is that the martial mineral waters, iron in substance, and in general all the preparations of this metal, a considerable part of which at least passes into the blood, as the experiments of M. *Menghini* shew, are the best remedies that can be employed in the chlorosis, in which disease we know that the blood is almost totally discoloured.

This red colour of blood is subject to some variations, in different circumstances. It is believed, not without probability, that the action of the air gives to it more lustre and vividness. It is certain that the blood of the pulmonary vein and of the arteries, is of a more exalted red than the blood of the veins; and Dr. Priestly has made curious experiments which shew very sensibly the great influence of the air on the red colour of the blood.*

## BONES.

BONES are the most solid parts of animals, and they owe this solidity to the great quantity of earth of which they are almost entirely composed. They contain also (besides the fat part of the marrow, which are only interposed) a considerable quantity of the same animal gelatinous substance which exists in the flesh and in almost all the other parts of animal bodies. *See* JELLY.

This gelatinous matter may be almost entirely separated by long and strong decoctions in a large quantity of water, or by dissolving the earthy part in the nitrous acid diluted with water, as M. *Herissant* has done after *Stahl*. Combustion, or calcination to whiteness, is another more expeditious method of obtaining the earth of bones entirely deprived of all its gelatinous part, when the intention is only to examine this earth, the nature of which has been entirely unknown till lately.

Chemists might well be embarrassed with the earth of bones, as on the one side, it exhibits with acids all the phenomena of calcareous earths, and on the other side, it wants the characteristic property of these earths; namely, the property of being converted by fire into quick-lime. Accordingly, several opinions were formed concerning the nature of the earth of bones. Some chemists considered it

* Concerning the influence of air on the colour of blood, see the *Treatise on the various kinds of permanently elastic fluids*, page 112, second edition.

it as a combination of calcareous with argillaceous earth; others thought it resembled the magnesia of Epsom salt; and the most prudent remained doubtful, till further experiments should produce new light. These experiments have been made in Sweden, and published a few years ago. They consist in extracting from bones, even when they have been calcined to whiteness, by means of the vitriolic acid, a saline, fixed, and vitrescible matter, which acts as an acid: is analogous to that obtained from fusible, or phosphoric salt of urine; and like this salt, is capable of forming *Kunkell's* phosphorus, by combining with phlogiston.

I have only been informed of this discovery, by the *Gazette, Salutaire de Bouillon*, October, 1775. It is there said, that Mr. *Henry Gahn*, a physician at Stockholm, has communicated a process for extracting from bones the saline matter in question; and that Mr. *Scheele* had ascertained, that the earth of animals was composed of a calcareous substance united with the phosphoric acid. This discovery, continues the author of the article of the Gazette, belongs to Mr. *Gahn*, and has been confirmed by later experiments.

It appears then, that these two chemists partake equally of this discovery. I presume, that having applied vitriolic acid to the earth of bones in a sufficient quantity for the reciprocal saturation of the two substances, they have separated, by washing, the selenitic matter formed in the operation; and that after filtrating all the acid liquor, they have exposed it to evaporation. I believe also, that the Swedish chemists judged, from the liquor becoming thick towards the end of the evaporation, or from some other sign, that it was the same saline matter which is called phosphoric acid; for it was said by them, that when they mixed some charcoal powder with this matter, and distilled the mixture, a phosphorus similar to that from urine was obtained, by a heat not exceeding that which a luted glass-retort could bear.

Another process is also mentioned for extracting this phosphoric acid from bones. It consists in dissolving bones in nitrous acid, in adding to this solution vitriolic acid, till more selenites is precipitated, and in distilling, or evaporating the liquor, in order to expel the nitrous acid which is now become disengaged, and the excess of vitriolic acid, if there should be any. Thus is obtained a residuum similar to the preceding, and with which phosphorus may be also made.

These fine experiments shew, that the earth of bones is saturated, at least in part, with the same acid, or phosphoric salt, which acts as the acid in the fusible salt of urine. The Swedish chemists say, what is very true, that if phosphorus cannot be immediately obtained from bones, the reason is, because the salt, or phosphoric acid engaged

engaged in a calcareous earth, or in a fixed alkali, cannot quit these bases to combine with the inflammable principle with which alone it can form phosphorus; and therefore the calcination of bones does not prevent the saline matter from being afterwards extracted from them by means of acids.

A discovery of this importance required to be verified with the greatest care, and accordingly M. *Poulletier de la Salle*, author of the French edition of the London Pharmocopeia, whose zeal and abilities are well known, and with whom I have the advantage of prosecuting chemical researches relative to medicine and animal œconomy, having proposed to me to make this verification together, we attempted it, and after several trials, we obtained, from hartshorn calcined to whiteness, by the intervention of the vitriolic acid, the saline matter mentioned by Mr. *Scheele*, at first of the consistence of a syrup; and afterwards, by evaporating it to dryness, and melting it in a crucible, in order to purify it, it became a vitreous matter, which being mixed and distilled with powder of charcoal, yielded a very fine phosphorus, which Messrs. *D'Arcet* and *Rouelle* saw taken out of the receiver. I shall not enter here into the detail of the experiments and observations which we made on this matter, because our researches are not yet finished. But several chemists, especially M. *Rouelle*, and M. *Prousse*, a young artist of great hopes, being now also occupied on this subject, we have reason to hope for the knowledge of some interesting facts. I am informed by M. *Rouelle* that a larger quantity of phosphoric salt may be obtained from uncalcined, than from calcined bones. This quantity is not yet determined. But after what we have hitherto observed, I am inclined to believe that three or four ounces may be obtained from a pound of hartshorn. We do not yet know whether the bones of all animals yield this phosphoric saline matter, and in an uniform quantity. Many experiments, and much time are required, to decide these questions. The facts which are now ascertained by facts well verified are, that the earth of bones is essentially a calcareous earth, forming a selenites with the vitriolic acid, and calcinable into quicklime, after it had been separated from the vitriolic acid by means of a fixed alkali, and well washed; as M. *Poulletier* and I were convinced from our experiments; and that if it cannot be converted into quicklime while it is united with its acid or phosphoric salt, the reason is, because this saline matter, which is of itself very vitrescible, and capable of vitrifying other bodies, begins to vitrify the earth of bones, whenever it is exposed to the heat requisite to convert calcareous earth into quicklime.

These are the experiments which seem to prove that the earth of bones is essentially calcareous, or at least that it is mixed with a large quantity of true calcareous earth. That we might know whether the earthy salt, almost insoluble in water, which we had obtained

obtained from mixing vitriolic acid with earth of bones, had the marks of ordinary selenites; after we had well washed this matter, we digested it during two hours with a lixivium of pot-ash, which did not appear to produce any sensible effect. We then filtrated and evaporated the liquor, by which means we obtained a laminated salt, which appeared to us to have all the characters of vitriolated tartar.

The earthy matter which remained upon the filter, was very white, friable and insipid. We calcined it during two hours with violent heat in a German crucible placed in an air-furnace. After this calcination, this matter was white, moderately agglutinated into a mass at the bottom of the crucible. It had an acrid alkaline taste. It was not much diffused by pouring on it distilled water; but this water thereby acquired the acrimony of lime-water. We filtrated it, and added to it some mild fixed alkali, upon which it deposited a copious white precipitate, as lime-water does. Lastly, a crust was formed on this water, like the cream of lime.

Although the calcination which we effected of the earth of bones deprived of its phosphoric acid, and of the vitriolic acid employed in the process, was not complete, since its extinction in water was not accompanied with heat, the marks of quicklime which we observed, are sufficiently sensible, to shew that this earth is essentially of calcareous nature, and that if in its natural state it does not exhibit all the marks of calcareous earth, the reason is because it is combined with phosphoric salt or acid.

Does not saline matter fit for making phosphorus, found first in human urine, and now in bones of animals, reside in many other animal substances? Experience alone can ascertain this point. *See the Article* PHOSPHORUS *of* KUNKEL, for the properties of the phosphoric acid.

## *Addition to the Article* BORAX, *of the former Edition.*

BORAX. Notwithstanding the experiments which have been made on borax and the sedative salt, chemists are not yet decided in their opinions concerning the nature, principles, and even some of the properties of these saline substances. This uncertainty induced Messrs. *Cadet* and *Beaumè*, both of the academy of sciences, to apply their researches upon this subject. But as these two chemists do not agree, neither in all the facts which they relate, nor in the consequences to be deduced from these facts, I will only relate in a summary manner the results of their experiments, without giving any preference to the opinion of either, because I think, that in fact several of the contested points are still doubtful, and cannot be cleared up without further experiments.

M. *Cadet*

M. *Cadet* preferred the crude borax to the refined as the ſubject of his experiments, and the kind which he uſed is that known in commerce under the title of *Borax of China*. From this borax he ſeparated by means of ſolutions and filtrations a whitiſh earth, on which he made many experiments, which are related in the fifth volume of the *Memoires des Scavans Etrangers*. One of the moſt remarkable of theſe experiments is that, in which he obtained from this earth a regulus of copper, which he depoſited with the academy. M. *Cadet* thinks that this regulus is one of the principles of borax or of ſedative ſalt. Mr. *Beaumè*, on the contrary, is of opinion that this metal is only found accidentally in borax, and that it proceeds from the veſſels in which this ſaline matter is prepared. The proof of this is, that in whatever manner pure borax is examined, it gives no mark of copper. M. *Cadet* anſwers theſe objections by experiments which ſhew that copper may be ſo diſguiſed by its union with different ſaline matters, that it cannot be diſcovered by the ordinary trials; and eſpecially by the action of volatile alkali, which is the uſual, and thought to be the moſt certain. The different combinations which he made of copper led him to the compoſition of a kind of artificial borax, which has the property of ſoldering well ſilver and copper. He announces that he has made on this ſubject ſome new experiments, which he will ſoon publiſh.

The earth which is ſeparated from crude borax, during its purification, contains, according to M. *Beaumè*, much ſedative ſalt. He has extracted ſome of this ſalt from that earth by the ordinary method of ſolution, filtration, evaporation, &c. but more eaſily by addition of an acid. M. *Beaumè* has alſo aſcertained, that even in the decompoſition of refined borax, a ſmall exceſs of acid favours much the ſeparation and cryſtallization of the ſedative ſalt. But M. *Cadet*, although he agrees with M. *Beaumè* in the good effect of an exceſs of acid in operating upon borax, is not of the ſame opinion reſpecting the earth of crude borax. He affirms, that having made repeated lixiviums of large quantities of this earth, theſe lixiviums when filtrated and evaporated did only yield a pellicle with rain-bow colours on the ſurface of the liquor, and even that this pellicle was not ſedative ſalt, but a matter which, when perfectly dried, was quite inſipid, and as little ſoluble in water as ſelenites and gypſum. M. *Cadet* adds, that when theſe lixiviums of the earth of borax are evaporated, if the pellicles are allowed to precipitate, inſtead of removing them as they form, the liquor acquires a colour towards the end of the operation, and alſo an urinous ſmell; at which time, he ſays, all the pellicles, which had precipitated, diſappear entirely, the liquor acquiring then the taſte of borax, and really containing a certain quantity of this ſaline matter, which may be thence obtained by cryſtallization.

M. *Cadet*

M. *Cadet* concludes from these experiments, that the earth in question is nothing but borax, the aggregation of whose parts had been broken and disunited by the water, and whose regeneration is effected by the same means by which it had been decomposed.

Mr. *Beaumè* agrees that some borax may be obtained from the earth that is separated in the purification of that salt; but as it is only by means of the portion of sedative salt which it still contains, it is necessary, he says, to add to it a quantity of mineral alkali proportionable to the quantity of sedative salt, and sufficient to saturate it, and reduce it to borax. Mr. *Beaumè* concludes from thence, that by adding at first a sufficient quantity of mineral alkali to the lixiviums made of crude borax, in order to purify it, the whole quantity of the borax may be at once procured, the earth containing one of its principles.

Before M. *Baron* had published his memoirs on borax, nothing was known decisively on the nature and pre-existence of sedative salt in borax. *Homberg* and several other chemists have thought that the sedative salt was composed partly of the acid employed in the process for obtaining it. But since M. *Baron* has made his experiments, most chemists have been of opinion with him, that sedative salt existed ready formed in borax, that acids do nothing but separate it from the mineral alkali, do not enter into its composition, and that consequently there is but one kind of sedative salt, this salt being always the same, whatever acid may have been employed to disengage it.

On this important point, M. *Cadet* has declared himself to be of the opinion of those who, before M. *Baron*, believed that the sedative salt was a new compound, resulting from the union of certain principles contained in borax with the acids employed in the process. Besides the experiments which he has already published in support of this opinion, he hopes to prove shortly, "That sedative salt is not ready formed in borax, and that it partakes "not only of the acid employed to disengage it, but also that "it contains a portion of the basis of sea-salt contained in "borax, and that it is owing to this same alkaline basis, "that cream of tartar owes the solubility which it acquires when "combined with sedative salt in the new neutral salt of M. *de la* "*Sone*, which M. *Cadet* considers as a compound, consisting of "five different principles. (Mem. de l'Academ. 1766, p. 365.) "Sedative salt, according to M. *Cadet*, may be combined in several "different modes with different salts, which when thus combined "do not shew their properties by the usual methods of discovering "them. For instance, he combined sedative salt with pure nitre, "and in this compound, he could easily distinguish the peculiar "cold taste of nitre. He observed also, that by solution and cry-

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"ſtallization, he could ſeparate the cryſtals of nitre. But never-"theleſs, this compound does not fuſe on burning coals, nor by "this method yield any fixed alkali, as M. *Cadet* ſays."

M. *Beaumè*, however, maintains firmly the opinion of M. *Baron*. He not only affirms that ſedative ſalt exiſts ready formed in borax, but he alſo announces, that by following one of the proceſſes mentioned in Mr. *Pott*'s diſſertation, he has been able to make ſedative ſalt, by combining the acid of fat with an argillaceous earth, by means of a digeſtion or maceration of a mixture of fat and clay continued during ſeveral years, in which mixture neither the acid nor the baſis of ſea-ſalt entered.

Ever ſince ſedative ſalt has been known, it has been ſuſpected, that it contained an acid. Moſt chemiſts have believed that this acid is the vitriolic, although ſome, as profeſſor *Melteſer*, M. *Bourdelin*, and M. *Cadet*, are of opinion, that it is the marine. M. *Cadet* mentions ſome effects on metals produced by marine acid, and calls to ſupport his opinion, the fine experiments of M. *de Laſſone*, related in the memoirs of the academy of ſciences for 1757, in which we are told that a ſalt very ſimilar to ſedative ſalt was obtained in a combination with marine acid.

M. *Cadet* is convinced from many experiments, particularly by waſhing ſedative ſalt with ſo great a quantity of water, that of fifteen ounces of ſalt, one only remained, which he drained carefully on blotting paper; that this ſaline matter does always retain an exceſs of acid, turns to red the blue colours of vegetables, and makes a ſenſible effervescence when united with an alkali. He maintains that this exceſs of acid is common to all ſedative ſalts, with whatever acid they may have been prepared. But this able chemiſt announces at the ſame time, that he will ſoon prove that theſe ſedative ſalts differ from each other, according to the kind of acid employed in their preparation, and that the ſedative ſalt, or the materials of which it is formed, do not conſtitute one half of the whole quantity of matter contained in borax, as M. *Beaumè* had ſaid. Finally, the later obſervations of M. *Cadet* turn upon the combinations of different ſedative ſalts with the ſeveral kinds of alkalies, mineral, vegetable, and volatile, whence he formed different kinds of borax, all which are capable of ſoldering, more or leſs perfectly. Sedative ſalt alone has this property, as M. *Cadet* has obſerved.

CALXES (METALLIC). By this name are diſtinguiſhed the *earths* of metals deprived of phlogiſton and charged with gas. They may be deprived more or leſs of the inflammable principle by ſeveral means.

The firſt is by diſengaging their phlogiſton in open air, and by a *calcination*, or rather by a *combuſtion*, ſimilar to that of all other combuſtible bodies.

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The ſecond is by expoſing metals to the action of acids that are capable of taking from them the inflammable principle; and of communicating to them a gas. Such are the vitriolic, and eſpecially the nitrous acids. This kind of calcination is made in the humid way, and by *ſolution*.

Laſtly, the third method is by detonating the metallic matters with nitre. This method depends on the two former ones, is the moſt effectual, and moſt expeditious.

The earths of metals thus calcined and deprived of their phlogiſton, and charged with air or with gas, by the means above mentioned, have properties which diſtinguiſh each of them, concerning which, it is proper to conſult the article of each of the metallic ſubſtances. But they have alſo properties which are general and common to them all.

Metals do not only loſe their characteriſtic properties as metals by calcination, but they alſo ſuffer the following changes:

The more exactly the metallic matters are calcined, the more they loſe of their fuſibility; ſo that ſubſtances which are very fuſible, ſuch as tin and regulus of antimony, are rendered, by a compleat calcination, that is, till they become very white, infuſible, and among the moſt refractory bodies; which fact proves that phlogiſton is the principle of the fuſibility of metals.

Metallic ſubſtances become then ſo much more fixed, as they loſe more of their phlogiſton. This property is leſs ſenſible in metals, from the fixity which they have naturally, than in ſemi-metals, which are volatile, while they have their metallic form, and whoſe calxes become exceedingly fixed, as appears evidently in the inſtance of diaphoretic antimony, which reſiſts the moſt violent fire without ſubliming, and which recovers all its volatility when it is reſtored to the ſtate of regulus by addition of phlogiſton. This proves that phlogiſton is eſſentially volatile, and that it communicates its volatility to certain bodies with which it combines.

Metallic earths become leſs ſoluble in acids, and particularly in nitrous acid, by being deprived of phlogiſton, as we may perceive from crocus martis, when well calcined, from calxes of tin, of regulus of antimony, &c. Hence we are led to conclude, that the ſolubility of metallic ſubſtances by acids, and particularly by nitrous acid, depends on the intervention of phlogiſton: for if calxes be reduced by adding phlogiſton, the metals reſulting from that reduction will then recover their ſolubility.

What we have ſaid concerning the general changes produced by calcination of metallic matters, upon their fuſibility, their fixity, and ſolubility, may alſo be applied to their opacity, their ſpecific gravity, in a word, to all their metallic properties, which are always diminiſhed ſo much more in metallic calxes, as they are more perfectly dephlogiſticated. This ſeems to indicate, that if

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an entire and perfect calcination of metallic substances could be effected, they would then have no metallic property, and perhaps they would not specifically differ from each other, and only be one and the same kind of earth. This is certain, that when the calcination of metals has been too long continued, their calxes become irreducible, or at least with much more difficulty reducible; and this reduction is always made with loss, so that the quantity of metal originally calcined is never again obtained.

Although metallic calxes are essentially different from calx of stone or quicklime, they have nevertheless some similar properties, particularly those which relate to fixed and volatile alkalies. Thus, for example, fixed alkalies receive from metallic calxes, the same causticity and properties as from quicklime; and volatile alkali may be separated from sal ammoniac by metallic calxes, and particularly by minium, as it may by quicklime; and it is thereby rendered more active and deliquescent. We have seen at the beginning of this article, that there are several methods of reducing metallic matters to a calciform state. All these calxes have common properties, which are those I have mentioned, but they have also properties peculiar to each, according to the nature of their respective metals, and also perhaps according to the methods used in their preparation. But the true cause of these differences, or even the true state of metallic calxes, are very far from being known. This subject, which would furnish matter for very important researches, has scarcely been touched upon, and may be considered as entirely new.

A very few modern chemists only have begun to consider it. They have chiefly attended to one striking phenomenon, which appears to affect metallic calxes in whatever manner the metals may have been calcined. I mean the weight acquired by most metals during their calcination. I say only *most* metals, because it is not yet proved that this effect happens to all. But since it has been actually observed in many of them, we may suppose that this phenomenon is general, as is well explained by M. *Morveau*, who possesses the true genius of natural philosophy and chemistry. Let us describe this phenomenon. If we reduce a metallic substance to an earthly state, either by burning, that is, by calcining it, or by dissolving it in some chemical agent, and afterwards precipitating it from that solution, we may observe very generally, that the absolute weight of the earth or calx which results from this operation, is greater than that of the metal before it underwent this alteration; and on the other side, when these calxes are by any means restored to their metallic state, it is found that this augmentation of weight ceases, so that the metal thus revived, weighs rather less than more than it did before its calcination. Various opinions have been formed concerning the cause of these

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very ſurpriſing effects. *Lemeri*, who was unacquainted with the doctrine of phlogiſton, explained all this eaſily, by ſaying that the augmentation of weight of metallic calxes aroſe from the particles of fire, which he ſuppoſes united with theſe calxes. *Meyer* and his partiſans, although they were acquainted with, and admitted the theory of phlogiſton, explained no leſs readily the above deſcribed phenomena, by attributing them to the *acidum pingue* or *cauſticum*, which they carefully diſtinguiſh from the inflammable principle. But other philoſophers, not well ſatisfied with theſe ſuppoſitions, which ſeemed not ſufficiently ſupported by proofs, have recurred to theories more laboured, and which are at the ſame time compatible with the doctrine of phlogiſton. One of the moſt ingenious of theſe theories, is that in which fire and phlogiſton are conſidered as a matter not poſſeſſed of weight, or rather as poſſeſſed of a property contrary to gravitation. This idea has been unfolded, and ſupported by proofs by M. *Morveau*, in a manner very capable of making an impreſſion on the beſt underſtandings. But it is eaſy to perceive how difficult it is to arrive at evidence and demonſtration in a matter ſo obſcure as this is at preſent.

Since the late reſearches into gaſes, the idea of theſe fluids being concerned in the calcination of metals, and in the augmentation of weight gained by that operation, has been ſuggeſted. Dr. *Hales* had obſerved, that metallic calxes contained *air*, and that this air contributed to their augmentation of weight. Dr. *Prieſtley* has alſo made ſeveral experiments tending to eſtabliſh this fact. But we are chiefly indebted to Meſſrs. *Lavoiſier* and *Bayen* for a number of experiments made on this ſubject. M. *Lavoiſier* conſidering the known phenomenon of an effervescence, which always accompanies the revival of a metallic calx, ſuſpected, with much probability, that this effervescence was cauſed by the diſengagement of a gas which ſeparated from the metallic calx when it reſumed the ſtate of metal; and in order to be convinced of it, he made many reductions of minium in cloſe veſſels, to which was adapted an apparatus for receiving and meaſuring the gas expelled during theſe reductions. The quantity of gas was found to correſpond pretty exactly with the exceſs of weight which the minium had over the lead whence it was prepared, and with the loſs of weight which the minium ſuffered during its reduction into lead. Alſo, the loſs of weight ſuſtained by the charcoal employed in theſe reductions, was ſcarcely ſenſible when compared with the quantity of gas produced. The ſame reſults nearly followed from reducing metallic precipitates. Laſtly, the examination of the properties of the gaſes diſengaged in theſe ſeveral reductions, when made by means of a combuſtible matter, having convinced M. *Lavoiſier* that they were the ſame as that obtained from calcareous earths and alkalies, he has thence concluded, with much probability, that the

the increase of weight gained by metallic earths, is owing to an aerial matter, or gas, which is united with them, and which contributes to their state of metallic calxes.

It is natural to any person who makes an important discovery, to consider the consequences which may be deduced from it, especially when these consequences happen to overthrow a famous and received theory, because these discoveries thereby become more important. Accordingly, M. *Lavoisier*, when he published the above mentioned experiments, appears to have been tempted to infer from them, that the metallic state of calxes was owing merely to their being united with a considerable quantity of gas, and that nothing more is required to restore them to their metallic state, than to deprive them of this matter; which opinion, if it were proved, would destroy the whole doctrine of phlogiston or combined fire. Nevertheless, this able philosopher has resisted, at least hitherto, that temptation, and has refrained from an absolute decision on this delicate question. His prudence deserves the more praise, as it shews him to be possessed of the true spirit of chemistry. For in fact it is only they who do not really know this excellent science, who can imagine that such inferences can be readily drawn, and that a single fact, even supposing it were well established, could be sufficient thus at once to overturn the fine fabric of one of the most important theories which the genius of chemistry has ever erected, and which receives from an astonishing number of demonstrative experiments, a support and strength, which must appear irresistible to those minds who are able to comprehend the whole, and their relations in one collected view.

M. *Bayen* also, well known by several good analyses of mineral waters, has lately published in the Abbé *Rozier's* journal, some experiments which are analogous to those of M. *Lavoisier*, and has drawn from them similar consequences, which appear to him to be very decisive. The title of Mr. *Bayen's* dissertation is, *Chemical Essays, or experiments made on some mercurial precipitates.* It is well known that mercury exhibits phenomena similar to the calcination of other metallic substances, in the preparation of the *precipitate per se*, and in the solutions of mercury by acids.

M. *Bayen* has preferred these calxes of mercury to minium and other metallic calxes as the subjects of his experiments, and in this respect he had an advantage over M. *Lavoisier*; because the mercurial calxes resume their metallic state with much less heat, and thereby many of these operations are facilitated, the principal difficulty of which arises from the necessity of using close vessels, in order to retain and collect the gas that is produced during these reductions.

M. *Bayen's* experiments consist in exposing mercurial precipitates to the action of fire, in retorts to which was adapted an apparatus

 of

of receivers for collecting and measuring the gas produced. The precipitates of mercury which were the subjects of his experiments, were separated from the solution of this metallic matter in the nitrous and marine acids, by means of alkalies fixed and volatile, caustic or not caustic, and by quicklime or lime-water.

This able chemist treated these different precipitates in his pneumato-chymical apparatus, with different degrees of heat, without addition, and likewise with addition of powder of charcoal.

In each of his experiments he obtained, first, a portion of the solvent and precipitant employed; Secondly, a quantity greater or less of revived mercury, or fluid quicksilver; Thirdly, more or less of a gas, the quantity of which was proportionable to the quantity of revived mercury. And it was also observed, that in those cases where the calxes were totally revived, the quantity of fluid quicksilver obtained, was always one eighth or one tenth less in weight than the quantity of the precipitate before its reduction, allowance being also made for the excess of weight which these precipitates gained from the portion of chemical agents that they retain in their precipitation.

These fine experiments of M. *Bayen*, gave him an opportunity of making other interesting observations; such as, the inflammation, explosion, and fulmination of the mercurial precipitates, when they are first mixed carefully with a certain proportion of flowers of sulphur, and then exposed to heat. He also observed the remarkable effects of fixed and volatile alkalies, which did only partially decompose corrosive sublimate, and converted the rest of it into sweet mercury, while lime-water procured a much more complete decomposition of this mercurial salt.

The phenomena of the reduction of mercurial precipitates, with regard to the production of gas, and the difference of weight, are analogous to those which M. *Lavoisier* has observed, by reducing minium in close vessels. M. *Bayen* had deduced the same consequences, namely, that all metals reduced to the form of earth, or of calx, owe this state to the gas which unites with them during their calcination by fire, or by chemical solvents; that to this substance the augmentation of weight is to be attributed, which they acquire during their calcination; and that this gas separates from them during their revival. These consequences resulting naturally enough from the accurate experiments of these two philosophers, appear to me very probable, and seem to announce an important discovery.

But these able chemists have gone a good deal further. I have already said, that M. *Lavoisier* had conjectured from his experiments, that the inflammable principle does not contribute materially, and by its direct union, to metallic reductions; and I ought to add, that M. *Bayen* having been able, in the course of his experiments,

, by means of a ſtronger or longer continued heat, to re-
ally, or almoſt totally, a precipitate of mercury into fluid
ver, without addition of any inflammable matter, did at
cide, from this ſingle fact, in favour of the conjecture pro-
y M. *Lavoiſier*, as if it were a demonſtrated truth, which
to overthrow the whole doctrine of phlogiſton, or of fire
ed in bodies.

ithſtanding the ſincere eſteem which I have for the talents,
the fine experiments of M. *Bayen*, I muſt ſay, that he
ded too precipitately on an affair of ſo much importance;
n the more ſurprized at this, as in every other part of his
, he ſhews the moſt rational doubt, and moſt judicious cir-
ction. "The following experiments (ſays M. *Bayen*,) will
eive us with regard to the doctrine of *Stahl*; in relating
, I ſhall not make uſe of the terms uſed by the diſciples of
who will be forced to relinquiſh their doctrine on phlo-
, or to maintain that the mercurial precipitates here men-
d, are not metallic calxes, although ſome of their moſt ce-
ed chemiſts have thought that they are; or laſtly, to con-
hat there are ſome metallic calxes which can be reduced,
ut the concurrence of phlogiſton."

experiments to which M. *Bayen* here refers, are the re-
of mercurial precipitates without addition of inflammable
in cloſe veſſels. To ſhew that they are by no means
of affecting the doctrine of phlogiſton, ſo well eſtabliſhed
, confirmed and explained ſo ſucceſsfully by chemiſts of
t order, it will be ſufficient to obſerve, firſt, That al-
it were proved that mercury, ſilver, and eſpecially gold,
ey are reduced to the form of calxes and precipitates, did
any thing of their inflammable principle, this would not
doctrine of the principle of inflammability, ſince the only
ence would be, that in ſome metals, this principle is ſo
ly connected and combined, that they can reſiſt opera-
hich the other metals cannot, without being decompoſed;
h has been ſaid to be the caſe ſince phlogiſton has begun
lked of, and which is in a great meaſure true. Secondly,
on the contrary, it were proved, that mercury, ſilver, and
ld, loſt a part of their phlogiſton, as well as the other
(which is M. *Beaumé*'s opinion, and which I believe to
poſſible,) the reduction of theſe metallic matters in cloſe
and without addition of inflammable matter, would not
r oblige us to relinquiſh any part of the theory of the prin-
inflammability. For it would be a ſufficient explanation
oſe, that the quantity of this principle which gold, ſilver,
rcury can loſe, in the operations by which theſe metals are
to the form of calx, is ſo ſmall, that the quantity of



metal

metal which cannot be reduced from want of addition of phlogiſton, is ſo infinitely little, in compariſon of the quantity of the reſt of the metal which is reduced, without having any occaſion for addition; that we might be induced to believe that the whole of the metal had been reduced, although ſome may actually remain unchanged.

Let us even go ſo far as to ſuppoſe, that theſe metals are much more ſuſceptible of calcination than they have been hitherto believed to be, and that nevertheleſs, they may be totally revived in cloſe veſſels, without addition of inflammable matter? How would this ſuppoſition make againſt the doctrine of phlogiſton? Nothing elſe can be inferred, unleſs that this is one of the caſes in which the diſengaged fire may be changed into combined fire. The partiſans of the theory of *Stahl* will always ſay, that theſe metals cannot take the form and the properties of metallic calxes, without loſing a part of their phlogiſton, and that if they have recovered their metallic properties in cloſe veſſels, without addition of inflammable matter, the reaſon is, that diſengaged fire, or the matter of light, which is neceſſary in all theſe reductions, and which penetrates both cloſe veſſels, and the metallic calx, finds in this calx, a body which already contains a good deal of it in the ſtate of combination, and which has the greateſt aptitude to reſume and retain enough of it to recover its metallic ſtate. Whence it happens that a portion of the light with which it is penetrated in the operation itſelf, is fixed in its union, becomes phlogiſton, and again reſtores the metallic ſtate. What reply can one make to thoſe who will thus explain the fact in queſtion? I own I know of none, and I believe that we may thence conclude, that neither the reductions of metallic calxes in cloſe veſſels, without any other addition than that of the diſengaged fire with which they are penetrated, nor the proofs of the exiſtence of a gas in theſe calxes, and of its expulſion during their reduction, do affect in any degree the theory of phlogiſton, and while no other facts more deciſive can be adduced in oppoſition to it, thoſe who admit it, will not be inclined to make any change in the eſtabliſhed language, nor the ſlighteſt reſtriction to their doctrine.

With regard to the gas, which appears to be in a great meaſure, the cauſe of the augmentation of weight of metallic calxes; becauſe *Meyer* ſays, that his *cauſticum* or *acidum pingue* does alſo unite to theſe calxes, M. *Bayen* is much inclined to conſider gas and cauſticum to be the ſame thing. The circumſtance which ſeems to favour the opinion of *Meyer* is, that moſt metallic calxes have a degree of cauſticity, which they are capable of communicating to alkalies, particularly to the volatile alkali of ſal ammoniac, when it is diſengaged by their means. But beſides, that quicklime, ſo far from communicating a gas to other matters, as metallic

calxes do, is on the contrary very much disposed to be united gas, and to lose its causticity by this union; it is sufficient to re the properties which *Meyer* attributes to his causticum, hose which have been ascertained to belong to all the gases, specially to that of calcareous earth, to be convinced of the al differences, and even of the incompatible qualities which e observed in these two substances.

eover, there is a circumstance in the reduction of mercury e vessels, which was not known to M. *Bayen*, because he did amine the nature of the gas obtained in his experiments: is circumstance deserves the greatest attention. It consists, that the gas obtained from mercury during its revival with n of inflammable matter, is totally different from that which ngaged from the same mercurial calxes, revived without n. The former gas extinguishes fire, and kills animals in-eously, while the latter is five or six times fitter for respira-nd combustion than the atmospherical air. Whence can so ous a difference proceed? It certainly has some cause, and use must be a very powerful one. The gas which is disen-during the reduction of mercury with addition of inflamma-tters, seems to be of the same nature as that of calcareous, of alkalis, of the spirituous and other fermentations, has been called *fixed air*;* and which I call *mephytic gas*. the nature of this gas not being understood, may we not ure, that the principle of inflammability is one of its consti-parts, together with common air; and if this be the case, it well separate from the mercurial calxes, without suffering eration, when this separation is assisted by a combustible, which gives to the mercury the quantity of phlogiston that essary, in order to reduce it into fluid mercury; but when calxes are exposed to violent heat in close vessels without n, then their reduction into fluid mercury, is effected only eans of the phlogiston of the gas which is united with the, and according to this supposition, we easily conceive, that s deprived of the phlogiston which mercury has taken from s reduction, ought to approach to the state of common air, n air so much purer, as it may have been more perfectly ogisticated in this operation. The name of *dephlogisticated* which Dr. *Priestley* has given to this excellent air separated metallic calxes reduced without addition, would perfectly with it, and these reductions of metallic calxes, without on of inflammable principle, would not in this supposition h any objection to the theory of phlogiston. A further pro-

 bability

is described in the Treatise on Gas, under the name of cal-s gas.

bability is given to this idea, by considering that the reductions of metallic calxes without addition of combustible matter, are much more difficult, and require a much greater heat, than those which are effected in the common method, by means of some inflammable matter. These are indeed only conjectures, and even are but little supported by experiment, the present state of our knowledge of the subject of gas, not admitting any thing much more accurate; but they are nevertheless at least *possible*, and are not inconsistent with the great phenomena of chemistry.

We may therefore conclude, that nothing has been yet alledged which is capable of subverting the theory of phlogiston. *See the articles* CAUSTICITY, QUICKLIME, FIRE, GAS, PHLOGISTON, *&c.*

CAUSTICITY. Causticity is that sharp and corroding quality, which many substances possess, such as the mineral acids, especially when concentrated, alkalies fixed and volatile, quicklime, arsenic, corrosive sublimate, lunar crystals, butter of antimony, and even most other salts with metallic bases.

All these substances when introduced into the stomach and intestines of animals in a sufficient quantity, according to their respective degrees of strength, affect the animals who have taken them more or less disagreeably, sometimes give violent pain, and occasion death. When we consider only their malignant effects, we call them *poisons*, or *corrosive poisons*, to distinguish them from other deadly substances, in which a corrosive quality is not sensible.

The same substances applied externally upon the skin, and the flesh of animals, excite inflammation, and pain similar to what is occasioned by fire. They produce eschars, suppurations, corrosions, excavations, and eat away the flesh. As from time immemorial, these matters have been used in medicine and surgery, to draw the humours to the external parts of the body, there to excite salutary suppurations, to open abscesses, or to consume excrescencies and proud flesh, and that independantly of the sensation of burning, which they occasion, they produce in some respects the effect of a body actually burning, they have been called *caustics*, and thence the word causticity has been derived.

Lastly, when these acrid substances are applied to unorganized bodies, such as all bodies excepting animals and vegetables, they shew evident marks of their peculiar action, by the motion, effervescence and heat, which are excited in such mixtures. And as after these signs of re-action are over, we find that all the integrant parts of the body acted upon, have been separated from each other, and combined with those of the caustic substance, so that there has happened a solution of the former, and an union of its parts with the latter into a new compound; in considering the acrid

and

caustic substances, with relation to their effects in chemical
ations, they have been called *chemical agents*, or *chemical solvents*.
ence it follows that the action of corrosive poisons, of caustics,
of chemical solvents, is essentially the same, and that it may
omprehended under the general name *Causticity*; and, that
causticity is nothing but the dissolving action of the caustic
ances, that is to say, it is the force with which their integrant
tend to combine, and unite with the parts of other bodies.
indeed, if we examine the stomach and intestines of ani-
killed by corrosive poisons, and the wounds to which sur-
have applied caustics, we find that the animal matters have
more or less corroded, consumed, and dissolved; and that
oison or caustic has really combined with the oily, saline,
y, watery, and gelatinous parts of the organs on which it
and that it has formed new compounds with these parts,
sely in the same manner, as when aqua-fortis has acted upon
e of iron, we find that the surface of this iron is corroded,
ved, hollowed, and that the parts of the aqua-fortis have
d with those of the iron into a new compound.

e causticity and dissolving power of all chemical agents, being
nd the same quality, and being also the proximate cause of
compositions and combinations, natural or artificial, we may
perceive the importance of having clear ideas of whatever has
n to causticity, of knowing, as far as we can, wherein it
s, how to augment, diminish, produce, or destroy it in a
nce. But this is no small difficulty; for whatever is con-
, as causticity is, with the first springs of the universe, is
inaccessible to the efforts of the human mind. In such sub-
we can only form conjectures; which are not, however,
it their use, when they can connect a great number of facts,
ew the analogy and relations, which subsist between them.
osophers did not endeavour to explore the cause of cau-
, till some of them began to reason upon the great phenome-
chemistry. The most natural idea, and which must first
t itself, was to attribute this quality to the presence of the
of fire, on accounts of the striking resemblance between the
of fire, and those of caustics, or chemical agents. Accord-
this opinion was first adopted, and is even now very gene-
eceived by those chemists, who wish to have a decisive opi-
n this subject. The fine theory of *Stahl* concerning phlo-
or concerning the effects of fire considered as one of the
ples of combustible bodies, has not a little contributed to con-
is opinion. In fact, we cannot doubt that fire possesses
ity in the most eminent degree, and that it is the most pow-
of all caustics, and since it is proved, that fire enters and
self as a principle in many compound bodies, and is always

ready to resume its essential activity, entirely or partly, according to circumstances; nothing is more natural than to attribute to the action of igneous particles, the causticity of all those substances, which possess this quality. Lastly, it is very possible, and even probable that fire contributes directly, and by its own causticity, to that of certain bodies, and in certain circumstances, as I shall explain more fully. Accordingly *Lemeri* has attributed the causticity of quicklime, of alkalies, of acids, &c. to the igneous particles inserted between the parts of these substances. But this man, justly celebrated as a practical chemist, had the fault of attempting to explain every thing; and he did indeed explain every thing with great ease, because his explanations were not examined with accuracy or depth, and he adopted readily whatever ideas were suggested by first appearances.

This explanation of causticity by the particles of fire, which *Lemeri* supposed to be contained in caustic substances, would have remained among the many conjectures, which being neither evinced by solid proofs, nor confuted by demonstrative experiments, are supported by an air of probability, which satisfies many persons, if the late M. *Meyer*, a very good chemist of Osnabruck, had not endeavoured to place it amongst those great theories, which stand the test of examination, and which throw much honour on those who support and establish them, by all the proofs of which they are capable. M. *Meyer* has done every thing that could be done for that purpose. An exact inquiry into the properties of lime-stones, into the phenomena of their calcination, into the effects of the causticity of quicklime, and of the causticity which it communicates to alkalies fixed and volatile, into the manner in which these several substances acquire and lose their causticity; many new experiments, and many chemical facts, before known, but now brought into one point of view with genius, and profound reasoning, are become, in M. *Meyer*'s work, the basis of a system, which he has rendered his own. This system, which at bottom is only the explanation, which we have said was before given by *Lemeri*, consists in establishing, that there is only one substance essentially caustic; that this substance is the matter of fire or light; that all caustic compounds owe their causticity to this principle; that they lose this quality in proportion as they are deprived of it, and become more caustic when they combine with a larger quantity of it. What M. *Meyer* has added to *Lemeri*'s explanation is, that he does not suppose with *Lemeri*, that fire, absolutely pure, can combine in bodies, so as to become the principle of their causticity; but fire connected in a certain degree with a particular matter of an acid quality, and forming with this acid a kind of compound principle, in which the matter of fire, without having the activity of pure and disengaged fire, does nevertheless preserve activity

ivity enough to be highly caustic, and to be capable of commu-
cating this quality to the different bodies, with which it is capa-
e of combining. Thus is constituted what he calls *acidum pingue*
*causticum*. The most seducing part of M. *Meyer*'s attempt, is,
at in his experiments, he has traced, with a good deal of saga-
y, the progress of this pretended causticum, from one combina-
n into another, observing the changes, which happened in the
operties of the body which transmitted it, and in those of the
dy which received it, as *Stahl* has done, with regard to phlo-
ston or perfectly combined fire.

A system founded on one part, upon natural effects no less sen-
le to the ignorant than to the learned, and supported on the other
rt, by a well-contrived course of chemical experiments, as M.
*yer*'s was, could not fail to have many partizans. It accord-
gly so happened. Most German chemists, among whom is M.
*rner*, the translator of this Dictionary into the German language,
ve adopted, and warmly defended it. Several good French
actical chemists, have declared themselves in favour of it. M.
*aumè* in particular, is so pleased with it, that this able chemist
s made it the basis of all the explanations that are given in his
*ymie experimentale et raisonnée*. But in order to extend its use as
uch as possible, M. *Beaumè* has not confined himself, as M.
*eyer* did, to consider as the sole *causticum*, or principle of all
usticity, nothing but the matter of fire connected to a certain
gree with a particular acid; but he rejects the *acidum pingue* of
. *Meyer*, and declares that it is fire itself, as fire, which is the
e caustic and principle of all causticity; that this element may
, and actually is found in every kind of combination, from the
ost gross, which is that of oils, of charcoal, of metals, &c. to the
te of fire, pure, or almost pure, which he supposes to be its state
the most violent caustics, as the mineral acids, quicklime, caustic
kalis, and other substances. As in fact fire is spread every where,
thus supposing it may have different degrees of combination,
e may, with the utmost facility, explain a great part of chemical
enomena. Thus, for example, if limestone should, from being
ild and in no degree caustic, become acrid, caustic, and active,
having been exposed to fire, M. *Beaumè* sees clearly, along
ith *Lemeri*, that the cause of this surprising change, consists in the
troduction of the particles of fire, between the particles of the
mestone. All the causticity of quicklime, the heat which it
xcites when mixed with water, its saline properties, &c. are
used by a quantity of pure, or almost pure fire, that combines
ith the stone during its calcination. If fixed and volatile alkalis
ecome more caustic and deliquescent by application of quicklime,
nd if quicklime loses its causticity in proportion as it augments
hat of the alkali, M. *Beaumè* presently understands, as also does
M. *Meyer*,

M. *Meyer*, that the alkalies takes possession of all the causticum, or almost pure fire which was contained in the quicklime. If the mineral acids are very caustic, it is because they contain much of the causticum of *Meyer*, or of the almost pure fire of *Beaumè*. If we ask Messrs. *Meyer* and *Beaumè* why acids, which are very caustic on account of their contained causticum and almost pure fire, should, when they combine with quicklime and alkalies, which also owe their causticity to the same igneous principle, form a compound which retains little or no causticity, they immediately answer, that the causticum or almost pure fire, separates from these caustic substances in the time of combination, and they adduce as a proof, the heat observed in the time of their action on each other. M. *Beaumè* has even provided himself with one resource more than M. *Meyer*, to extricate himself from this embarrassment, which is, that as he admits fire in all kinds of combinations, he may also say, that the cause of the above-mentioned phenomenon is, that the almost pure fire of the acids and alkalies, puts itself into another state of combination, different from that in which it existed while it was united with the disengaged acids and alkalies.

As every caustic has a most violent taste, and as the most caustic substances are also those which make the strongest impression on the organs of taste, it is very probable, that causticity and taste are essentially one and the same quality, as I have observed in several places. But this quality, being susceptible of greater or less degrees, preserves the name of causticity when it is strong enough to occasion pain, and acquires the name of taste when it has only strength enough to make a sensible impression on the organ, without the sensation of pain. If fire be the only caustic substance in nature, it follows, that this element is also the only matter which can have taste; that it is the principle of taste, and to which all other matters owe their taste. Accordingly M. *Beaumè* has not failed to advance this proposition, and makes very great use of it in explaining an infinite number of phenomena, and of the properties of bodies. Thus the taste which all saline substances have more or less sensibly, and which is considered as one of their distinguishing characters, proceeds, according to M. *Beaumè*, from this cause, that all saline matters contain fire, either pure, or almost pure, or in some certain state, and that they cannot derive this quality from any thing but the principle of taste, which is fire. We may easily perceive that with so fertile principles, there cannot be any difficulty in explaining every thing.

But this theory of *Lemeri* renewed by M. *Meyer*, although well unfolded, extended and supported by *Meyer* and many other chemists, seemed to be destined to enjoy only a transient reign. For in the very time when M. *Meyer* was giving to his theory its greatest lustre, Dr. *Black*, a Scotch Physician, established one of these

hese capital discoveries which make an era in the history of scien-
es, and which entirely contradicted the doctrine of the chemist of
Osnabruck. It is also very remarkable, that it was in making experi-
ents upon the same substances, quicklime and alkalies, that these
wo chemists have drawn consequences quite opposite. So true it
, that in experimental philosophy, we cannot be too attentive in
xamining every circumstance that occurs in our experiments, and
hat we cannot be too guarded in drawing conclusions in order to
stablish general propositions.

Quicklime and alkalies having the property of receiving a con-
derable augmentation and diminution in their causticity, of
ansmitting this quality to, and of taking it from each other, were
he true matters on which it was necessary to make experiments, in
rder to acquire new knowledge on causticity in general. Messrs.
*Meyer* and *Black* have both perceived this, and were accordingly
etermined to make these substances the subjects of their experi-
ents. We have already mentioned the result of M. *Meyer*'s trials.
We now proceed to those of Dr. *Black*.

The researches of Dr. *Black* were accompanied with the disco-
ery, that calcareous earths and stones are in their native state,
turated with water, and with a large quantity of a volatile and
lastic substance; that the effect of the calcination of these stones,
as to deprive them of their water and volatile substance, which
as at first called *fixed air*; that calcareous stones acquired as
nuch more causticity, and the other qualities of quick-lime, as
hey were more perfectly deprived of this volatile substance. Dr.
*Black*'s experiments prove moreover, that alkalies fixed or volatile,
efore they have been altered by fire, or by quick-lime, are in a
reat measure saturated with this same volatile matter or gas; that
his saturation renders them capable of crystallization, and consi-
lerably diminishes the causticity of which they are susceptible;
hat if these alkalies be mixed in a proper proportion with quick-
ime, this latter substance deprives them of their gas, and is there-
y saturated, by which means the quick-lime, which owes all its
causticity to its having been deprived by calcination of this gas,
now resumes all its former mildness, and the other properties which
t possessed before calcination; and that at the same time the fixed
r volatile alkalies being now deprived of this matter by quick-
lime, acquire the highest degree of causticity, and of deliquescence,
of which they are susceptible.

The singular substance which bears so great a part in the cau-
sticity of quick-lime and of alkalies, becomes very sensible, not
only in all the experiments which we have mentioned; but it be-
comes more palpable and even visible, when it is made to pass
from one compound to another. If lime-stone be calcined in close
vessels, as has been done by *Hales*, *Black*, *Jacquin*, the Duke of
*Rochefoucault*

*Rochefoucault* and others, the gas or volatile ſubſtance which is ſeparated by the fire, may be collected into receivers. When matters that contain much of this gas, as uncalcined calcareous earths, and mild alkalies, are diſſolved by any acid, the gas becomes very ſenſible by the conſiderable ebullition and tumultuous effervescence which it excites, while it is diſengaged from theſe ſubſtances. It may be collected and retained in a bottle, and ſubjected to experiments as Dr. *Prieſtley* has done, and may be ſeen at the article *gas*. The impoſſibility of collecting and of including a ſubſtance thus in a veſſel, is certainly not a ſufficient reaſon for denying its exiſtence, or calling it into doubt, when there are other demonſtrative proofs of it, as ſome perſons who pretend to reaſon upon the ſublimer parts of chemiſtry have done, with regard to the exiſtence of *Stahl*'s phlogiſton, which they have lately treated as an imaginary being, becauſe it cannot be collected and rendered ſenſible. This argument cannot, however, be employed againſt the gas, which we treat of, ſince it may be included without mixture in a bottle.

On the other ſide, it is no leſs demonſtrated by facts, that quicklime and alkalies poſſeſs all their cauſticity when they are deprived of this gas, and they loſe their cauſticity when they are ſaturated with it. This diſcovery, one of the moſt important that has been made ſince chemiſtry has been cultivated, has, as may be well ſuppoſed, entirely put to flight the *igneous particles*, the *cauſticum*, and the *pure*, or *almoſt pure fire*. Accordingly, it has given high offence to all thoſe chemiſts to whom the matter of fire furniſhed ſo convenient an explanation of the phenomena of cauſticity.

Some perſons, in eluding this thorny queſtion concerning the cauſe of cauſticity, diſpute about the name *fixed air*, which has indeed very improperly been uſed, after *Hales*, to denote the gas of which we are treating, and which has been applied alſo to other gaſes of a different nature. They have drawn advantage from this confuſion of names to attack this great diſcovery, in repreſenting it as nothing more than what *Hales* had before ſhewn, although in fact it is very different, eſpecially in this reſpect, that *Hales* made no application of his experiments towards explaining the cauſe of cauſticity. Others, who eſpouſe the doctrine of fire being the cauſe of cauſticity, have denied or conteſted many of the facts on which the theory of Dr. *Black* is founded. Moſt of thoſe who have taken the pains to verify or extend theſe experiments, have given ſolid anſwers to every objection, and have added the confirmation of ſeveral new experiments. Amongſt theſe, M. *Lavoiſier*, one of the chemiſts of the academy of ſciences, has performed this taſk with great ſucceſs. This philoſopher, by means of weight and meaſure, has added the ſeal of authenticity to theſe facts, while he

ie verified them with great accuracy, in presence of commissaries
amed by the academy for this purpose.

It is then well demonstrated, that the caustic, or mild state of
alcareous earths, and of alkalies, is not owing to the presence or
bsence of *igneous particles*, of *causticum*, or of *almost pure fire*, but
o the separation or union of a volatile substance or gas, and water,
vhich put them into a state of saturation, more or less complete,
ccording to the general rule of all the other operations in chemis-
ry. What can then be opposed to this demonstration, by those
hemists who can conceive no other cause of causticity, but the
ction of igneous particles? Will they say that the gas itself is no-
hing but air and fire? This answer would be good, if calcareous
arths and alkalies became so much more caustic, as they contain-
d more gas. It would also be well to prove that this gas, which
known to extinguish fire, contains really more fire than other
odies. But the contrary happens to be the truth, as we have
hewn; and accordingly, this supposition would sooner prove,
hat fire is not the immediate cause of causticity; for if it were, the
onsequence would be, that the energy of this quality is dimi-
ished in proportion as the cause which produces it is encreased,
nd that it would be encreased by diminishing its cause; proposi-
ons which certainly cannot be maintained. Can it be possible that
n attachment to the doctrine of *causticum* and *fire* can be carried so
ar as to attempt to reconcile this contradiction, by saying, that
he *causticum*, or *almost pure fire* of the caustic earths and alkalies is
n a certain state, different from another certain state in which it
, when it is contained in the gas? There could not, I confess,
ny reply be made to such an answer, for the same reason, that it
ould be useless to reply to the epicycles and crystal-skies ima-
ined by the defenders of *Ptolomy*'s system, whenever any new
henomenon was discovered in the course of the stars, contradic-
ory to this system.

After we have mentioned facts which demonstrate so clearly as
hose above related, that the effect of causticity cannot be attribu-
ed to the action of igneous particles more or less combined, or
ncombined, it would be superfluous to add weaker proofs, if the
ubject were not of such importance in chemistry, that nothing re-
ative to it ought to be neglected. I will add then here some con-
iderations which tend to throw light on this matter, and which
rove in a general manner, and applicable not only to the causti-
ity of earths and alkalies, but also to the causticity of all other
ubstances, that the cause of causticity, or of the want of this qua-
ity, does really depend upon nothing else than the different
tates of saturation.

The first observation which I shall make, will have for its ob-
ect the comparison of the properties of the most caustic substances
with

with those of fire. I say then, that if the action of caustics were not properly their action, but the action of the fire that is united to them, the greater their causticity, the more analogous ought their properties be to those of fire, since this causticity is not supposed to be owing to any thing, but to a fire more abundant and more uncombined and pure in these caustic bodies, than in others which are not caustic. On the other side, the most characteristic property of uncombined and active fire is that of occasioning the sensation of heat, and the rarefaction of the bodies on which it acts. These positions being established, the *causticum*, or *almost pure fire*, ought to produce these effects of uncombined and active fire in a manner so much more decisive, as the caustics are endowed with a greater causticity; but experience proves completely the contrary. If a thermometer be plunged into a caustic alkali, into the most concentrated vitriolic and nitrous acids, into solutions of silver, of mercury, of butter of antimony, in a word, into the most violent known caustics, no greater degree of rarefaction will appear in the fluid of thermometer than if the instrument had been left in the air, or plunged into water, oil, or other mild liquor. We may then conclude, that the pretended fire of caustic substances is not either more abundant, or more pure, or more uncombined, or more active than that of other bodies.

It is true, that at the time when caustics or chemical solvents act, a degree of heat is frequently excited, which is sometimes considerable, and proceeds even to ignition. Those who acknowledge fire as the cause of causticity, avail themselves much of this phenomenon, in saying, that this heat is a sensible effect of the *causticum*, or *almost pure fire*, which the caustics or solvents contain, which not being able to enter as a component part in the new compound resulting from the solution, is disengaged and escapes, while at the same time it manifests its presence in the most evident manner; and we must confess, that this is one of their most plausible arguments. I nevertheless think that this argument can only satisfy those whose attention is totally absorbed by a particular fact which strikes them, so as to prevent them from perceiving in this phenomenon the effects of a cause much more general.

It is a fact demonstrated by numerous and incontestable experiments, that the collision of hard bodies produces heat, and even ignition. Hence there is no hard body whatever, which is not heated more or less, and even becomes luminous, in proportion to the percussions, collisions, or frictions which it suffers. And this is precisely the case with the solid parts of caustics, or chemical agents, or of the bodies on which they act, and from which they suffer an equal reaction in the time of solution, or in the act of all the combinations that are accompanied with violence and rapidity. The heat therefore that is produced in all

their

e chemical operations is no more the effect of the portion almost pure fire, or causticum, than it is the effect of these ciples, when two flints are rubbed violently against each other, which certainly have no property that approaches in any de- to causticity.

he phlogiston or combined fire, which enters into the combi- on of so great a number of compounds, may undoubtedly pro- e, and does really produce a considerable effect in many oper- ns of this kind, since it is capable of becoming disengaged from whenever the parts of bodies which contain it, receive a suffi- t collison to produce ignition, and so that it may be separated n them by means of air. It then augments the heat and light, it is from this cause that, the rubbing of two pieces of wood nst each other, produces not only a burning heat, but even e and conflagration, while the collision of two flints, excites a smaller degree of heat, and a weak and transitory light. we ought to take notice, that this kindling of combined fire circumstance, which may accompany the effect of causticity, ough it be entirely distinct, and unconnected with it, as is nowledged by M. *Meyer* himself, who very carefully distin- hes his causticum from phlogiston, and also by M. *Beaumé*, , when he calls his almost pure fire the principle of causticity, ar from confounding it with phlogiston, since the latter prin- e is fire, so far from being pure, and is so combined, that the pounds which contain it most abundantly, as grease, oils, s, &c. are actually the mildest and least caustic of all substances. ogiston is not then in any of these cases the first cause of the t produced by the action of caustics or chemical solvents, but ely a cause concomitant with this heat, an auxiliary cause fit to ment it, and to render it more durable.

he best method of finding the truth, and of shewing it to others ifficult matters, where it does not at once appear, is to be candid, issemble nothing that may be favourable to the opinions con- ed, to search also carefully all the objections that may be made nst the opinion that is adopted, and to present them in all their e. This is also the only method of bringing to light matters in obscurity, as this is. I will therefore, by no means, omit tioning the fact which appears to me the most favourable to the ion that attributes causticity to the matter of fire.

Ve have said that heat is commonly excited when caustics ex- se their action, and I have shewn how I conceive that this effect be explained, without admitting a greater quantity of fire in stics than in other bodies. But in the detail of these effects, a umstance occurs which I am the less inclined to omit, because it le a great impression on myself. It is that the degree of heat duced when acids combine with alkalies or absorbent earths, is

very

very different according to the ſtate or theſe alkalies, that is, whether they be cauſtic or mild. It is very certain, that the heat produced when an acid acts upon a fixed or volatile alkali that is not cauſtic, or upon uncalcined calcareous earth, is inconſiderable, and that the heat is very ſtrong when the ſame acids act upon cauſtic alkalies, or upon quicklime. I have frequently repeated theſe experiments, and I have with ſurprize remarked this difference. I confeſs that this fact alone appears at firſt a proof that fire was the immediate cauſe of cauſticity, and I was forced to ſay with the partiſans of this opinion, that mild calcareous earth contains no more fire than other bodies, and therefore produces little heat, when it combines with acids; but that by calcination it retains a portion of the fire employed, and that this portion of fire retained, gives to it the properties of quicklime, renders it cauſtic, and in a word is what eſcapes when quicklime is combined with acids, and which produces the violent heat that accompanies this combination. This heat is ſenſible, it burns; how can ſo demonſtrative a proof be reſiſted? The ſame difference of heat having place between mild and cauſtic alkalies, I could ſcarcely avoid falling into the opinion of Meſſrs. *Meyer* and *Beaumé*, that as theſe ſaline ſubſtances acquire their cauſticity from quicklime, they owe it to the *cauſticum* or *fire almoſt pure*, which paſſes from the quicklime into the alkalies; which explanation ſeems to be further confirmed by the mildneſs which the quicklime reſumes, after having thus communicated its cauſticity, or its principle of cauſticity, to alkalies.

Theſe remarkable effects, and the reflexions which they naturally produced, held me, I confeſs, during ſome time, in a ſtate of uncertainty. On one ſide, I was preſſed by a kind of demonſtration founded on an experiment ſo ſenſible; and on the other ſide, I felt the greateſt repugnance to attribute cauſticity to the parts of fire, becauſe this ſyſtem has always appeared to me contrary to the nature of fire, and of all the great phenomena of chemiſtry. The method I took to extricate myſelf from this embarraſſment was, to take care not to confine my attention to one circumſtance of the experiment, but on the contrary, to conſider carefully even its moſt minute details, becauſe a fact really proves nothing but what reſults from every particular accompanying it. But in the fact, which we are now conſidering, there is a circumſtance, which ſeems to give a ſatisfactory ſolution of the difficulty, and this is the effervescence which always accompanies the combination of acids with mild alkalies, or uncalcined calcareous earth, and which does not accompany the ſaturation of acids with cauſtic alkalies and earths. We now know that all the effervescences which happen in ſolutions and combinations, are owing to a diſengagement and evaporation of a volatile matter or gas, which ſeparates during the act of combination, from one or both of the combining

ſubſtances.

nots. We also know that the evaporation of volatile fluids, east, of many of these fluids, produces cold, and even a de- f cold proportionable to their volatility, and facility of eva- on. This position being established, as a fact, whatever be use of this effect, it is no less certain, and it is very easy to ve, that if, as I do not in the least doubt, there is no more caustic than in mild alkalies and earths, these latter would ce in their solution by acids, the same degree of heat as the r, without the circumstance of the evaporation of their gas, , by occasioning cold, necessarily diminishes the intensity of at. Accordingly the caustic alkaline matters, which do not n any gas, and which dissolve without effervescence, produce their solution by the mere motion of their parts, all the heat they are capable of producing, because there is no cause to ck that heat; and on the contrary, the same alkaline mat- when mild, dissolve with much less heat, because the eva- on of the gas, and its consequent cold, checks considerably at, which, without this circumstance, would be as great as rmer.

these phenomena so interesting, prove the necessity of not ng, without reflexion, even from the most imposing appear- Who would not believe, since collisions, in general pro- eat, that those which are so evident in the solutions of effer- g substances, should not produce more heat than the perfectly il solution of caustic substances? The contrary, however ns. All these great movements of effervescence are accom- d with little or no sensible heat, while the burning heat re- g from the peaceable and silent solution of caustics, cannot ceived without surprise.

econd consideration which I ought to add here, concerning city, relates to the impression which the substances called make on the organ of taste. It appears certain that this ssion does not differ essentially from causticity; but solely in gree of its energy; for we see that the most caustic matters o those which have the strongest taste, and that those which rfectly free from causticity, are also totally destitute of taste. icity and taste are then not two different qualities, but one e same property, more or less strong and decisive in its effects, ave said in this article, and more fully at the article *salt*.

cording to what we have just said, if all causticity proceeded igneous particles, it would necessarily follow, that fire is also nly matter that is essentially sapid; and that all those sub- s which have taste, must derive this quality also from the hich they contain. This is a necessary and just consequence s system. M. *Beaumé* however, is the only person who has this consequence, and has declared, that fire is the only

ſubſtance in nature, which has eſſentially taſte, and is the proximate cauſe of taſte in all other bodies. As the mere impreſſion which pure fire makes on our touch and taſte, is nothing but the heat and the burning, it follows from this ſuppoſition, that the moſt ſimple taſte of all, that which, if we may ſo expreſs it, is the element of all taſte, is nothing but heat or burning, and that when we taſte any thing, our tongue and our palate are really only heated, or in ſome degree burned. The great diverſity of taſtes does not make any difficulty in this ſyſtem, becauſe, while it admits that fire exiſts in compounds in a great variety of different ſtates, as M. *Beaumé* ſays, this great diverſity of taſtes will be eaſily explained by an equal diverſity of ſtates, in which fire may be in the different ſapid bodies.

So far the explanation may be ſuppoſed to proceed well. But the kind of ſenſation that is directly oppoſite to that of heat, that ſenſation which is ſo contrary to that of heat, that they mutually deſtroy each other, and cannot both exiſt in the ſame perſon at the ſame time, I mean the ſenſation of cold; how is it to be explained in this ſyſtem? This difficulty, which has not been foreſeen, appears to me to be very embarraſſing. For if the impreſſion of heat has a right to be conſidered as a ſimple taſte, and principle of all other taſtes, why ſhould not that of cold, which is equally ſimple, and no leſs ſenſible to our organs, have the ſame right? It does not appear that we can alledge any reaſonable motive for refuſing it. When water is heated, it gives to my tongue and palate the ſenſation of heat. I am told that this impreſſion is produced by the particles of fire contained in the water. When I let the water cool, till its temperature be equal to that of the human body, it makes no very ſenſible impreſſion upon my organs. It will then, I ſuppoſe be told me, that water, being naturally as inſipid as every other body, excepting fire, cannot now have any taſte, becauſe it contains no more of the principle of taſte, that is, fire, than other inſipid bodies. So far ſtill the explanation may perhaps ſeem to go on well. But when I let this water cool as much below the human temperature, as it was at firſt heated above it, and taſte it once more, it makes on the organ of my taſte an impreſſion no leſs ſenſible than the firſt, but quite oppoſite. If I aſk the cauſe of this new impreſſion, what anſwer can be given? If it be ſaid that the impreſſion of cold is not a taſte, I ſhall aſk, what right has then the impreſſion of heat to be conſidered as ſuch. And if it be admitted (for it cannot be conteſted) that they have an equal right; I will then ſay, that as cold is only produced by the abſence of fire, the cold ſenſation cannot be the effect of the action of igneous particles, and I ſhall thence conclude, that all taſte cannot depend on the action of thoſe igneous particles.

To

exhaust all the answers that may be imagined to such pressing
lties, will it be pretended, that the sensation of cold, as well
heat, proceeds from the action of fire, by saying that when
hotter than my body is applied to my organs, the igneous
les act upon those organs in passing from the water to my
in order to be equally distributed, or produce an equilibrium
t; and on the contrary, that when I put colder water into
outh than the temperature of my body, some igneous particles
rom my body to the water, in order to bring it to an equal
rature; that in this latter case, in which the sensation of cold
luced, as in the former, when the sensation of heat is occa-
, both these sensations equally result from the immediate ac-
f the parts of fire upon our organs, with the sole difference
heat, the action of fire irritates the parts of our body in quit-
he hot substance to enter into the parts of the organ of taste;
hat in cold it shakes the sensible parts of our body by its
nent, in passing from them to the cold substance. If this
were given, I would reply, that if the above explanation
dmitted, it must necessarily follow, that the impressions of heat
ld, proceeding equally from the action or impulse of the par-
f fire, their difference would depend solely on the difference
ctions with which these particles move; and that this ele-
must consequently be endowed with the property of produc-
at when it moves in a certain direction, for example, from
o left, and of producing cold when it passes in any other di-
, as from left to right. I shall say no more on this subject,
ave too good an opinion of the understandings of those whose
n I contest, to suppose them incapable of perceiving all the
ity and ridicule of such an answer. For the same reason, I
it needless to talk here of the frigorific fluid of *Muschenbrock*,
rts of which, might be supposed capable of exciting the sen-
of cold, as well as those of fire can excite the sensation of
For if we admit such a fluid, of which however none of the
of heat and cold prove the existence, it would be an absolute
ition of the principle contested, that fire is the sole cause of

m these observations, it appears as clearly demonstrated as any
of Natural Philosophy can be, that the proximate cause of
ity and taste is not the immediate action of the particles of
ire, or almost pure fire, or any causticum. Besides, it is easy
ceive, that if we were to admit the igneous matter or element
as the sole caustic and the principle of causticity and taste in
er bodies, that would not be establishing a general theory of
city, for we should not on that account, have a clearer and
precise idea of causticity, that is, of the state in which matter
eral ought to be, to have the caustic property, or to be en-

 dowed

dowed with a diſſolving action; ſince, when we ſuppoſe, that fire is the ſole ſubſtance ſuſceptible of this diſpoſition, the queſtion would ſtill remain in what this diſpoſition of fire conſiſts; and in Natural Philoſophy, we ought not to flatter ourſelves that we have gone as far in the diſcovery of the cauſes of the great effects of nature as the human mind is capable of, while we may hope to riſe higher than that kind of particular cauſes to which we at firſt have reached. Thus when we attribute cauſticity to the immediate action of fire, we do not truly aſſign the cauſe of cauſticity and taſte, ſince the queſtions ſtill remain why fire has cauſticity and taſte, and of what theſe qualities conſiſt.

But if it be aſked, what then is the true cauſe of cauſticity, I might anſwer plainly that I knew nothing of it, yet the opinion which I have conteſted, would not on that account be better founded than I have ſhewn it to be. However, I cannot now make that anſwer, although perhaps it would be the wiſeſt and the moſt reaſonable. I have explained my ſentiments upon this ſubject in many articles of the firſt edition of this work. It is neceſſary then that I ſhould explain them here as clearly as I can. But it will be not improper, before we enter upon this diſcuſſion, to make the following preliminary obſervations.

Firſt of all, I agree, that if diſengaged fire be a ſubſtance eſſentially fluid, and the cauſe of fluidity in all other bodies, as I think; this element muſt be conſidered as a remote cauſe of all cauſticity, ſince the effect of the actions of ſolvents or cauſtics cannot take place without the fluidity of the cauſtic, and of the body on which it acts, or at leaſt of one of them. Thus diſengaged fire has its influence in the production of cauſticity; but not as an immediate cauſe, that is to ſay, by the direct action of its own parts upon the body which ſuffers the effect of the cauſtic, but merely as being able to put the parts of the body in a neceſſary ſtate of mobility, that cauſticity ſhould have its effect. Thus the action of diſengaged fire is only a conditional cauſe of cauſticity, a *cauſa ſine qua non*.

Secondly, I agree that diſengaged fire is itſelf, a violent cauſtic, in the ſenſe that I ſhall explain, and that alſo, from the reaſons which I have juſt aſſigned, it has influence in producing this effect; that in many circumſtances, it may augment the cauſticity of bodies, as it really does in the caſe of ſolvents, whoſe activity is rendered greater, and in that of aliments, whoſe taſte is rendered ſtronger, by heat, than when theſe matters are cold.

Thirdly, It is very eſſential to recollect here, what I have ſaid at the beginning of this article, on the action of cauſtics and ſolvents; that two effects neceſſarily reſult from this action, namely, the ſeparation of the parts of the body acted upon, and the union of theſe parts with thoſe of the cauſtic or ſolvent, ſo that this ſe-

paration

on and this new union are two simultaneous effects and inse-
le from the same cause. When I say that these two effects
separable, I would not have it understood that the union of
arts of the body dissolved or corroded by the caustic, with
arts of this caustic, is always proportionable to its action, or
that it never fails to happen; for this assertion would be
ary to experience. But I say that the new union is the
of causticity, or of the dissolving power; that it is a
quence, or necessary dependant on this power, and that it
occurs as completely as circumstances can permit. The
nion is so far the end, and even the sole end or purpose of
on, it is a dependance and consequence so necessary, that
ut it, solution could not take place. The proof of this is,
he action of the solvent, or of the caustic, is absolutely pro-
nable to this union, that is to say, that if, after the caustic
oduced all its effect of solution, its parts are no longer ca-
of contracting any union with those of the dissolved body,
lvent preserves, after this solution, as much causticity or dis-
g power as it had before; that if, on the contrary, an inti-
nd perfect union of the parts of the solvent with those of the
dissolved, has followed the solution, the smallest appearance
sticity, or dissolving action no longer remains with the cau-
solvent; and that lastly, if this consequent union, or ra-
hat which accompanies the solution, is made more or less
etely, the caustic always retains a degree of causticity very
y proportionable, in an inverse ratio, to the intimacy of this
. These are facts established upon as many experimental
as there are operations in chemistry, and which cannot be
ted by any person who is really conversant in that science.
ese positions being established, what other idea can be reason-
ormed of the state of any substance that possesses the quality
causticity, which is demonstrated by facts to be nothing else
tendency to union, than to consider the integrant parts of this
substance as being so disposed, either by their figure, or by
terposition of some other substance, that not being able to
ogether with the intimacy to which they tend, they retain
atisfied force, by means of which they are determined to
with the integrant parts of any other kind of body, with
they may have the liberty of contracting an union more in-
than that which they have between one another?
en I examine a fixed vegetable alkali rendered as caustic as
be, I see that this substance has an extreme activity to cor-
nd dissolve whatever it touches, that its taste is acrid to a
that gives pain; that if it be deprived of water, it seizes
uid with a surprizing force, when mixed with it, or even
it from the air; that its deliquescence is extreme; that it

corrodes and reduces to a paste all vegetable and animal matters to which it is applied; and that it dissolves oils and fat effectually, and converts them into soaps. But what is the result of all these solutions made with such activity? Its dissolving power or causticity is constantly diminished in the same proportion as it is exercised, or rather, as I have said, in proportion to the intimacy and force of the union, which this caustic contracts with the substances on which it exerts its action. If, for instance, it has united with the volatile matter or gas of calcareous earths, as this light and almost aerial substance has too little solidity to contract with it the most intimate union, it preserves still, notwithstanding this union, a portion of its dissolving power, and it retains all the characteristics of a fixed alkali. But also, as it is combined to a degree with this gas, its causticity ought to diminish, and actually does diminish in proportion to this new union. Not only the acrimony of its taste is abated, but also it no longer acts as a cautery to animal flesh. So far from being deliquescent, it is capable of crystallization, and of being preserved, during its exposure to air, in form of dry crystals: It has no longer strength enough to dissolve oils and fat so effectually as is necessary for the combination of soap. The same observation may be extended to its other properties.

If, instead of uniting the alkali with gas, it be made to combine with oils and fat, it exhausts a greater part of its causticity on these matters, because it contracts with them a more intimate union than it does with gas. Accordingly the alkaline properties, and dissolving power, although they be still somewhat sensible in soaps, are nevertheless infinitely less so than in the alkali simply saturated with gas.

With acids in general, but particularly with vitriolic acid, the action of the causticity of alkalies, and its abolition which is the consequence of it, are manifested in a manner still more striking. Let attention be given to what happens to the most caustic fixed alkali, when it can act upon the vitriolic acid, which also is a powerful caustic; the integrant parts of these two corrosives are so disposed, that they can contract with each other an union, much more intimately than with most other substances. Accordingly they unite with great violence, and by this union they reciprocally exhaust their activity, so that after they are united, no causticity remains either with the acid or with the alkali. The new compound resulting from this union, called *vitriolated tartar*, scarcely retains a saline taste, and very little solubility in water. It is now scarcely able to shew marks of its action upon any body.

Lastly, if instead of combining caustic alkali with vitriolic acid, it be made to act upon a matter purely earthy, (which cannot be done without fusion by violent heat, on account of the force of aggregation

egation of the integrant parts of the earth) the action of this ie is exercised so completely upon the earthy matter, and the n which the parts of these two substances contract together, account of this action, is so strong, that the new compound, that e glass which is thus made, far from giving the least sign of icity, has not even the slightest taste, nor any saline property.

though all these facts be so well known to chemists, that they be reckoned trivial, I think it proper to collect them here, ing them together under one point of view, because the efforts have been made to explain causticity by the action of igneous les, or of a causticum, prove clearly that the natural conse- ces of this *saturation* which accompanies the action of caustics, which is the effect of it, has not been sufficiently understood ttended to. For the same reason, I shall also make some re- ons on several of the circumstances of the combinations of cs with bodies on which they exercise their causticity.

e may at once remark, in all the examples which I have ad- , the exact proportion that is maintained between the dimi- n of the causticity of the alkali, and the degree of force with this caustic adheres to the substances to which it unites. Of ese substances, gas is that with which its union is the st and least intimate, since quicklime, and all acids, even the st, can, without the help of heat, deprive it of this gas the greatest ease. Accordingly all the effect of the diminu- f causticity which this gas is capable of producing upon the , even when saturated with it, is only to render it capable ystallization, less deliquescent, less acrid, and less fit to be ined with oils and greasy matters, but the alkali still retains alkaline properties, so that when it is in this state, it is called or *ordinary fixed alkali*.

though oils and fat do not contract a very intimate union caustic alkali in the composition of soap, since these oils be separated without heat, by the weakest acids, yet this is stronger than that of alkalies with gas. For these oils can- e separated from alkalies by means of quicklime as gas may, the causticity of alkalies is more abated by oils than by gas. universally known that soap is less caustic, less solvent, and lkaline than the alkali that is most saturated with gas, and st crystallizable.

is also a truth acknowledged by all chemists, that any acids act a more compleat and stronger adhesion than oils with c alkali, and we also see that in all salts compounded of acids lkalies, the alkaline causticity is so diminished that it is not nisable, and disappears so much more completely as the nited with the alkali is more simple and more powerful.

I could thus trace the combinations of caustic alkali with a great number of other substances, such as sulphur, metals, arsenic, sedative salt, charcoal, the colouring matter of Prussian blue, &c. and I could shew the same proportion between the diminution of its causticity, and the intimacy of union that it is susceptible of contracting with each of these substances. But that I may not too much lengthen this article, I will confine myself to the union of alkali with purely earthy substances, by means of fusion; and I observe that this union in a perfect vitrification is the strongest of all, since it cannot be destroyed by any known intermediate substance, and since it resists the action of a most violent fire. It is therefore of all the combinations of caustic fixed alkali, that in which its causticity, and its other weaker saline qualities, are most perfectly abolished, and even to such a degree that if we did not know the composition of glass, none of its properties would shew that it contains much alkali *.

What I have said on the causticity of fixed alkali is applicable to that of acids, and in general of all other caustic substances. If I wrote only for readers profound in chemistry, they would themselves make these applications: it would be useless to adduce more examples, and even those which I have mentioned, would have been superfluous. But as the explication of the true cause of causticity, appears to me to be the sole foundation of all rational theory in this extensive science, I cannot forbear clearing up this matter to the understanding, and the conviction of persons of less extensive genius, who may find some difficulty in seizing all the relations, and in comprehending the whole of a grand number of facts.

I shall therefore give an example, which I have chosen, because it contains a particular circumstance, that merits attention.

When good nitrous acid is applied to quicklime, the causticity of the acid is exercised with violence and heat on this earth. When another portion of the same acid is applied with heat to tin, it acts upon the metal with the same violence and heat as upon the quicklime. But when we examine the result of these two mixtures, we find a very striking difference. The mixture of the acid and quicklime has no causticity, taste, or any of the characteristic properties of acids; whereas the mixture of the acid and tin retains on the contrary all the causticity and acidity of the nitrous acid. Whence proceeds so singular a difference. The partisans of *pure fire* or *fire almost pure*, or of the *causticum*, can say nothing, but that, during the action of the acid and quicklime upon each other, the fire of which these two caustics are full, and to which they owe their causticity,

* It is said in a memoir that gained the prize of the academy, that flint-glass retains no alkali. But this is a mistake. *See* VITRIFICATION.

city, ſeparates from them and thereby produces the heat ob-
l, and that in loſing their fire, they alſo loſe their cauſticity.
anſwer is ſufficiently clear; but it will not apply to the cauſ-
which remains with the nitrous acid, after it has acted upon
n. We muſt ſuppoſe that this acid, which loſes its cauſticity
it acts upon quicklime, does not loſe it when it acts upon tin,
ugh the heat and commotion which accompany this action be
ſt as conſiderable as thoſe which ariſe from the action of the
acid upon quicklime. We muſt ſuppoſe that the heat of the
on of tin, is cauſed by the diſengagement of the particles of
hat are combined with the tin, and which fly off from this me-
n preference to the particles of fire combined with the nitrous
but we could aſſign no reaſon for this preference, ſince on the
ary the phlogiſton of metals appears to be more ſtrictly com-
l than in nitrous gas.

t when inſtead of all theſe ſuppoſitions deſtitute of proofs, I
ine the ſtate of the two ſolutions, I ſee that in the ſolution of
klime, this earth has entirely diſappeared; that it has combined
the acid, in ſuch a manner that nothing remains but a tranſ-
nt homogeneous liquor: In a word, I am convinced from the
riment, that the reſult of the action of nitrous acid on quick-
, has been, that all its particles have united to all the parts of
quicklime, and I thence conclude that the tendency of combi-
on which the parts of theſe two ſubſtances had before their
n, in which their cauſticity eſſentially conſiſted, having been
fied by this union, which they have contracted with each
r, their cauſticity ought neceſſarily to be abolifhed or dimi-
d, in proportion to the intimacy of this union. I then pro-
to the examination of the ſolution of tin, and I find that this
l or its earth, after ſuffering all the corroſive and cauſtic action
e nitrous acid, has been only divided by this action, and has
precipitated in form of a white ſediment; in a word, that
arts have not contracted any union with thoſe of the acid, and
ence conclude, that as the cauſticity of the nitrous acid is no-
g elſe than the tendency which its parts have to union, and as
s exerciſed this tendency upon tin, but not ſatisfied all this
ency by its ſubſequent union with this metal; this acid ought
tain afterwards the ſame cauſticity and acidity as it had be-
; and this is what actually happens in the experiment. I now
which of theſe two explanations is the moſt ſimple, and beſt ac-
s with all the phenomena of ſolutions, combinations, ſatura-
s, that is to ſay, with all the grand effects, the knowledge
hich, and their relations, truly conſtitutes the ſcience of
niſtry.

have purpoſely choſen the example of the action of the nitrous
upon tin, not only to prove, that cauſtics preſerve their cau-
ſticity,

ſticity, when, after having exerciſed all their force upon a ſubſtance, they contract no union with this ſubſtance, but alſo that I might have an opportunity of making ſome remarks upon this phenomenon, which is more or leſs evident in almoſt all ſolutions and combinations. In fact, it ſcarcely ever happens in any of theſe operations, that, after the ſolution, the parts of the ſolvent, and thoſe of the body diſſolved, are united with all the force which they poſſeſs.

It is for this reaſon that cauſtics, after having exerciſed their action upon certain bodies with all their activity, preſerve ſtill more or leſs of their cauſticity, of their diſſolving power upon other bodies, and of their taſte. Sometimes they retain theſe qualities entire, or almoſt entire, as in our example of nitrous acid with tin. There are caſes of this kind ſtill more remarkable, namely, thoſe in which, notwithſtanding a ſtrong union of the parts of the ſolvent, with thoſe of the body diſſolved, the new compound is found to poſſeſs a ſtronger cauſticity or diſſolving power, than either of its component parts had before their union. *Sublimate corroſive*, and many other combinations of metals with acids, are examples of this effect, very worthy of attention. But this phenomenon, ſo far from furniſhing an objection, as at firſt view it ſeems to do, againſt the general rule of the diminution of cauſticity, being proportionable to the intimacy of the union of the parts of the cauſtic, with thoſe of the body on which it acts, is a new proof of the theory of cauſticity here delivered, as will be ſhewn at the article SUBLIMATE (CORROSIVE), and in ſeveral places of this work.

But to return to a more ſimple caſe, where the cauſtic preſerves all its cauſticity, after its action upon a ſubſtance, from want of the ſubſequent union with the parts of this ſubſtance; I mean to the cauſticity of *diſengaged fire*. I am far from denying that this element is poſſeſſed of even a great degree of cauſticity, when it is not combined; as I have already obſerved, it ought to have, and it has, in this reſpect, the ſame property as any other kind of matter: When its integrant parts are ſo diſpoſed or figured, that they cannot exhauſt upon each other, in the ſtate of aggregation, their tendency to union, this tendency remains entire, and is conſequently capable of being exerciſed on any other matter. I do not then ſay that fire is not cauſtic; but that it does not poſſeſs cauſticity, ſo as to exclude all other ſubſtances from this quality, and that it is not the ſole cauſtic, or principle of all cauſticity and taſte. What I have to remark at preſent, is, that of all cauſtics, fire ſeems to be the one whoſe integrant parts, although they may have as much or more tendency to union than thoſe of any other ſubſtance, do however the leaſt frequently unite with the parts of thoſe bodies on which it exerts its cauſticity; ſo that notwithſtanding

the violent effects of ſolution and ſeparation, which it produces, cauſticity remains entire, becauſe it does not continue com- ed with the bodies on which it acts. The diſengaged fire which acted upon moſt bodies, remains afterwards in the ſame ſtate the nitrous acid, after it has acted upon tin. It is only in parti- r caſes, that, after it has acted upon bodies as diſengaged fire, emains combined with the parts of theſe bodies, and loſes its ficity like all the other cauſtics, in following the general , that is in proportion to the intimacy of the union which it tracts.

believe I may conclude from theſe different reflexions and ob- ations, that cauſticity, the diſſolving action, taſte, all action, ort, of one matter on another, is nothing but the effect of the eral force with which all the parts of matter tend to unite, and ly themſelves to each other, with all the intimacy that can be itted by their bulk, their figure, the vicinity or interpoſition olecules of a different kind of ſubſtance, and other ſuch cir- ſtances.

hat in conſequence, every body whoſe integrant parts are ap- d to each other with all the force with which they tend in ge- l to union, has no cauſticity, no taſte, no diſſolving power.

hat the ſame may be obſerved of all bodies, whoſe integrant s are united to the integrant parts of another body, with all intimacy poſſible, that is to ſay, that the mixt or compound, lting from this union, has not, while it ſubſiſts, either cauſ- y, or taſte, or diſſolving power.

hat every body, whoſe parts are ſo diſpoſed towards each er, that the force, with which they in general tend to union, not be exhauſted by the union which they are capable of hav- with each other, or with other bodies, has a degree of cauſti- , taſte, and of diſſolving power exactly proportionable to the dency to union that remains not exhauſted.

hat laſtly, a body, whoſe integrant parts, however ſmall, or r to each other, ſhould be ſo diſpoſed by any cauſe, that they uld not contract any union or adheſion together, and conſe- ntly would poſſeſs all their tendency to union; in a word, a ſtance ſuch as diſengaged fire appears to be, would have, for t reaſon, the greateſt degree poſſible of cauſticity, of taſte, and diſſolving power.

Theſe poſitions being eſtabliſhed, if earth in general, if flints, inſtance, have no cauſticity, no taſte, no diſſolving power, ſole cauſe is, that its integrant parts are ſuch that they can ly repoſe on each other, and adhere together, with all the force th which they tend in general to union. The great hardneſs, en of the moſt ſimple and moſt homogeneous ſtones, which are all the ſubſtances known the hardeſt, is an evident and ſenſible

proof

proof of the extreme force with which their primary integrant p
are ſupported, and applied to each other, and in fact, if we did
admit this force, how would it be poſſible to form to oneſelf, l
not ſay a clear idea of hardneſs, but even any idea of this quality? w
it be ſaid, with the Carteſians, and with *Lemeri*, that the peculiar p
of earths and ſtones are crooked particles inter-twiſted with e
other? But how can we conceive that theſe crooked particles r
their ſeparation, if one does not ſuppoſe, that they themſelves
hard? and would not this be to explain hardneſs by hardneſs,
is, not to explain it at all.

If it were poſſible to ſeparate from each other the primary in
rant parts of the hardeſt flint, and to inſulate them, ſo that t
could not exhauſt upon each other, as in the aggregation of fl
the effort of their particular *gravitation*, or of their tendenc
union, it appears to me evident, that they would be capable t
of exerciſing this force in all its extent upon any other ſubſta
to which they might be applied; that when applied to the tong
they would not only give a ſtrong ſenſation of taſte, but alſo
they would violently cauteriſe the organs of taſte, or any other
of the human body; that they would unite with a ſingular acti
to the particles of air, or of water, in a word, to every ſubſta
which they could touch.

What we have hitherto not been able to do, with reſpec
earth, by any operation of art, nature does daily; at leaſt
certain degree, with reſpect to the earth which ſerves as the b
of marine ſhells. This earth is ſo attenuated and divided by
vital and organic action of theſe animals, that its integrant p
are found to be ſufficiently inſulated, and diſengaged to act u
water and gas, and to unite with them into a compound ca
*calcareous earth*. The integrant parts of calcareous earth, co
pounded each of earth, gas and water, have a weaker adhe
together, than the parts of pure and ſimple earth have, beca
the union which the purely earthy parts of the calcareous ea
have contracted with the water and gas, ſaturates to a certain
gree their tendency to combination; but, as it does not entir
exhauſt this tendency, it follows, that calcareous earth ought
have more diſſolving power, more diſpoſition to combine w
other ſubſtances than any other kind of earth that is not ſimila
diſpoſed. Accordingly, experience informs us, that calcare
ſtones are generally leſs hard than other ſtones, and that th
readily combine, not only with all diſengaged acids, but alſo w
acids already combined with certain baſes, ſuch as the earth
alum, metallic ſubſtances, and perhaps many others.

By the mere effect of heat applied to calcareous earth, its wa
and gas may be ſeparated. It thus may undergo, according to t
degree of heat applied, two changes very different, but very
markabl

kable, and perfectly consistent with the theory that I am en-
vouring to explain. If the degree of heat be strong enough,
only to separate its water and its gas, but also to bring it into
on, then when that heat ceases, its earthy parts approach
ards each other, unite into a vitreous aggregation, nearly as
ng as that of stones that are not calcareous, and the glass which
lts from this fusion, retains none of the properties of calcareous
hs, no dissolving power, no disposition to unite with acids,
with other substances on which the calcareous earths have a
nifest power of acting.

f, on the contrary, the degree of heat applied to calcareous
h be such, that it can separate its water and its gas, but too
k to make the remaining earthy parts to enter into fusion, then
se earthy parts cannot re-unite, because they are not at liberty
nove, that is, they have not the fluidity which fusion alone
ld give them, and also being deprived of their water and gas
which a great part of their tendency to union was exhausted,
y remain, merely by being deprived of these two substances,
owed with almost all the energy of this tendency, that is to say,
austicity, of dissolving power, in a word, of all the properties
ch characterise *quicklime*, and of which I shall speak more fully
he article *quicklime*.

s to the objection which might be drawn from air and water,
ch, although fluid, do not seem to have any causticity, not
n the smallest degree of this quality, which is taste, I am con-
ced that this objection cannot have the least foundation, but
ong those persons who, like the greatest part of mankind,
ge without reflexion, and from simple appearances. But a
losopher who would give proper attention to the properties of
se substances, will be soon convinced that they have, as well
ll other fluids, their proper degree of dissolving power and
e. Numberless experiments prove that air and water are
ong the greatest solvents in nature, though not the strongest;
it is therefore not possible but they must have taste propor-
able to their dissolving power. It is true, that this taste is
sensible; but every one knows that the sensations which the
pression of external bodies excites, are relative to the disposi-
n of our organs, and that custom particularly prevents our per-
ving impressions, which would otherwise appear very strong,
perhaps even painful and insupportable. From the first in-
nt of our existence, we are constantly exposed to the impression
air and of water, which is probably at first, very sensible, as
cries of infants beginning to respire seem to indicate. But
forget our first sensations, and uninterrupted custom renders
at last not sensible of some of them. The taste therefore of air
d of water is no longer perceived by us, for the same reason
that

that we are not ſenſible of the preſſure of the atomſphere, wh however is known to be very great.

Beſides, although it be true that the aggregation of a ſubſta is ſtronger in the ſtate of ſolidity, than in that of fluidity, and for this reaſon, the diſſolving power ſhould be more evident this latter ſtate, than in the former, it does not therefore foll that liquids or fluids have no aggregation. This aggregation ou neceſſarily to ſubſiſt always more or leſs completely, while integrant parts of the liquid are not ſufficiently inſulated, and parated from each other, to be abſolutely out of their ſpher mutual activity. It is however, only in this latter caſe that th parts can enjoy all the cauſticity or tendency to combination is proper to them. But we do not know what may then be cauſticity of air, and of water, probably it would be leſs ſtr than the cauſticity of earth and of fire. It is however cert that it would be much ſtronger than it is in their fluid and liq aggregation, which is the only ſtate in which the properties theſe ſubſtances have been hitherto conſidered. We cannot do that air and water become powerful agents in a great numbe chemical and phyſical operations, as well as fire and earth. Th conſiderations offer to chemiſts a career as new as it is importan be purſued, and there is reaſon to hope that ſome men of ge may engage in it. The diſcovery of *gas*, which is very rec and is, properly ſpeaking, only begun, gives reaſon to hope many others may follow. After we have ſufficiently aſcertai the exiſtence and properties of the different kinds of gas, we undoubtedly endeavour to find the nature of theſe ſubſtance different from all thoſe before conſidered. And who knows, i inquiry into the combinations in which air and water ente component parts, and which are not yet ſuſpected, will not th the greateſt light upon the nature and principles of gaſes? Am theſe ſubſtances, there are ſome which evidently contain an flammable principle; ſuch are thoſe which are diſengaged f liver of ſulphur, and from the ſolution of ſeveral metals by vit lic and marine acids. But that, which I call *mephytic gas*, which ſo far from being inflammable, ſuddenly extinguiſhes flame, when brought into contact with it, and inſtantly kills mals, whoſe properties in other reſpects partake a good dea thoſe of water and air, does it not ſeem to be compoſed princi ly of water and air; and is it improbable, that theſe two pri ples, which in their ſtate of aggregation, cannot, either of th combine intimately enough with quicklime and with cauſtic al lies to deprive them of their cauſticity, acquire this property consequently a ſolvent power, or a true cauſticity, when they ar diſpoſed, that their aggregation is much weaker than in their ordi ry ſtate, and when their integrant parts are not ſo intimately bo

n union, as to check all the tendency to combination, which new mixt possesses, on account of their aggregation being de-ed. We cannot now make any additions on this subject; perhaps the time will come, when we shall be able, by means experiments to establish a satisfactory theory on this important er.

seems to me that the result of what I have said in this article, at causticity is nothing but the effect of the force with which parts of caustics tend to unite with the parts of other bodies. if most of the chemists who have attempted to give a theory usticity, have been mistaken, as I think I have proved, the rea-s, that they have attended to one part only of the effect of caus-y, and have, as I may say, shut their eyes to the most essential mstance; an enormous fault in Natural Philosophy, into h it is surprizing that so many very good chemists should have n. For they, impressed solely with the solution of the parts of s on which caustics or solvents act, and with the tumult, heat, and even inflammation which accompany these solutions rtain circumstances, and seeing on the other side that fire, when gaged and in action, produces constantly these effects, they thence concluded, as the vulgar might, that causticity is only ffect of fire contained in caustics and solvents, without giving east attention to the new union which results from the parts of caustic with those of the body on which it has exercised its n, without considering that causticity always diminishes in ortion to the intimacy of this new union; that the caustic re-s as caustic as ever, if it does not continue united to the body h it has divided, that on the other hand it retains no causticity e combined as strongly as it can be with the parts of the body ved; lastly, without recollecting, that every solvent whose icity has been even the most completely abolished by the union h it has contracted with a body capable of producing this ef-pon it, resumes its causticity entirely, when it is disengaged y means from this union.

m very sensible that this tendency to union which I consider, many Natural Philosophers, as the sole cause of causticity, at the same time of the hardness of bodies, cannot be even rstood by many chemists; and that many artists, although wise very able, will always consider as chimerical a theory attributes to one and the same cause, hardness, insipidity, the ute want of a dissolving power in flints, and the violent caus-y of the most active solvents. But in a subject like this, we ot expect that all persons should be unanimous. I therefore n without regret the opinion of those, who not being capable neralizing their ideas, sufficiently to see Nature at large, are r pleased with fancying as many particular causes, as there are phenomena

phenomena to be explained, than to refer to one common and
verſal cauſe an almoſt infinite number of effects, on account o
conſiderable difference, even contrarieties, which they think
perceive between many of theſe effects; who, ſeeing that fir
very cauſtic ſubſtance, always very active when uncombined
which ſo eaſily reſumes its activity, rather chuſe to conſider
element as the ſole principle of all cauſticity, and conſequent
the ſole active matter that exiſts in nature, than to acknowl
that this ſame active force is not thus limited and attached to
one kind of matter, but that it is general, univerſal, common and e
tial to whatever is matter. Laſtly, I perceive that ſome will fi
difficult to underſtand that this active force is nothing elſe tha
tendency on gravitation which all the parts of matters have to
other, and which is not only the cauſe of the force with which
parts of the hardeſt ſteel adhere to each other, but alſo o
aſtoniſhing activity with which a corroſive acid diſſolves and
vours this very hard body.

I foreſee all the objections that may be made to ſuch a the
but on the other ſide, I ſhall have attained my purpoſes, and
ſiciently explained my opinion; if the philoſophers, who are
ſible of the ſimplicity and the general extent of the *Newtonian*
loſophy, ſhould think that I have made a rational application
to the chemical phenomena of cauſticity, of ſolutions, and of
binations, which, as I have ſaid, conſtitute properly the who
chemiſtry.

It is true that the active and general force of matter which *N*
*ton* denotes by the name of *attraction*, cannot be eſtabliſhed in
ticular Phyſics on proofs of the ſame ſort as thoſe on which
ſuppoſition of this force and of its law, is become the moſt
factory theory of the movements of the heavenly bodies, an
the ſyſtem of the world. The ſun, the planets and comets,
great maſſes of matter ſo few in number, and ſeparated from
other by ſpaces ſo conſiderable, that from the obſervations of
movements, and by the aid of a profound geometry, it has
poſſible to diſcover and demonſtrate the perfect correſponden
theſe effects, with the force which was ſuppoſed by *Newton* t
their cauſe; and this agreement, which is truly admirable,
changed that ſuppoſition into a truth almoſt demonſtrated t
perſons of good underſtanding. But particular phyſics are no
pable of the ſame advantages. For here an infinite multitu
inviſible atoms, inconceivably ſmall, act upon each other at
tances infinitely ſmall and not to be calculated. We cannot
any idea of their maſſes, of their velocities, or of their figures,
which, as the Count de *Buffon* has obſerved, ought neceſſari
have influence in their action. The perturbations are innum
ble, and it is conſequently almoſt impoſſible to demonſtrate

m

s of any calculation, the law according to which all these cor-
les act upon each other. But although this knowledge, if it
be acquired, would be a new and very strong proof of the
al action of all the parts of matter upon each other, especially
could demonstrate that the law of their action is the same as
f the heavenly bodies, or is the necessary consequence of it;
ay however, without this knowledge, perceive in general, that
great masses of matter act upon each other at great distances,
nallest particles of the same matter ought also to act upon each
at distances proportionable to their masses, since no reason
xist, why small bodies should be deprived of a property or of
ivity which is so obviously exerted in great bodies.

stly, it appears that this universal tendency of all these parts
tter towards each other is the most simple and general cause to
we can refer the explanation of the phenomena of Che-
; since no other cause can be assigned, and since the simple
r to those who should ask why matter is endowed with this
force, would be, that as the supreme Being chose that the
should exist as it does, it was necessary that matter should
the properties which it has, and particularly this active force,
ut which the heavenly bodies would not run in orbits round
ter; without which the elements of matter deprived of all
ular movement, would not join nor adhere to each other;
onsequently without which the total mass of matter, supposing
ible that it could in that case exist, would be an immense, and
nless liquid, that is, a true Chaos.

AUSTICUM of M. *Meyer*. This is considered by M. *Meyer*,
nixture resulting from the union of the matter of fire, or of
with a particular and unknown acid. This causticum, which
so calls *acidum pingue*, is according to him the sole caustic and
iple of all causticity. See the articles *acidum pingue*, *causticity*,
*lime*, and others.

*Addition to the Article* CLAY *of the former Edition.*

LAY. M. *Beaumé*, who has made many researches into the
nature of clay, the results of which are to be found in a me-
printed separately, and in his chemistry, having carefully
ated most of the experiments already made by the chemists
tioned in the former part of this article, agrees with them upon
most essential point, that is, on the perfect resemblance between
earth of alum when separated from its acid, and the earthy
of clays when purified from all heterogeneous matters, and
ecularly from vitriolic acid, a portion of which is found in
r most clays. But this good chemist being desirous to extend
knowledge in this and many other subjects, has conceived some

peculiar ideas concerning the nature of clay, and the cause of properties of this kind of earth. He considers the argillac and vitrifiable earths as one and the same species of earth, and principal fact on which he grounds this opinion is, that vitrif earth when precipitated from the liquor of flints by an acid, ha the properties of the earth of alum, and particularly that of for alum with vitriolic acid. This proves that the argillaceous e owes its origin to the vitrifiable earth, as *Stahl* has said of th well as of the calcareous and other earths.

But can it be hence inferred that there is no difference bet the earth of sand or flints and argillaceous earth, and ough even to apply to this latter earth, the epithet *vitrifiable?*

By the same rule we might, according to *Stahl*'s idea of calca earth, give to this also the name of vitrifiable earth: for it ha origin and properties common to both, which might authorise appellation; and on the other side, argillaceous earth has pr ties very peculiar, by which it is as much distinguished as cal ous earth is, from vitrifiable. Argillaceous earth has a bin quality, a peculiar ductility and adhesion to water, w pure vitrifiable earth never possesses, however finely it ma divided. It cannot serve as a flux to calcareous earth or gyp as vitrifiable earth does. It requires even greater heat, a larger quantity of fluxes than the true vitrifiable earth, to its vitrification. I know also another very important pro which I have ascertained by many experiments, by which it d from vitrifiable earth in a more remarkable degree than in th stances above-mentioned, even although the latter earth has fered the greatest division of which it is susceptible, and has made to approach as near as it possibly can to the argillaceous e by fusing it with a large quantity of alkali. The property meant is that by which pure argillaceous earth, or earth of a when combined with fixed alkali, is the most effectual of all k substances in making the red colour of madder adhere to cott thread. Vitrifiable earth, combined with fixed alkali, or in other form, does not possess this property. I shall further obs that this earth of the liquor of flints, also the earth of the ash vegetables, and the earth which precipitates spontaneously fixed alkali, although they be all fit for making alum by combi with vitriolic acid, are nevertheless very far from the state of and simple argillaceous earth. They differ singularly from latter earth, in being exceedingly fusible, which property they bably owe to a portion of fixed alkali, which is so intim united with them, that it cannot be washed away by any q tity of water. All these considerations incline me to think tha name of *argillaceous earth* ought to be continued, and that of *fiable earth* ought to be confined to the earth usually so called.

ſecond opinion peculiar to M. *Beaumè* concerning the nature ays, is, that the vitriolic acid is a neceſſary principle of theſe s and one of their conſtituent parts. He diſtinguiſhes in na- clays a very attenuated vitrifiable earth, but which not being ined with vitriolic acid, is not in the ſtate of clay, but is only f the materials proper for its formation. Finally, he applies ame and properties of clay ſolely to the combination of this with vitriolic acid. According to this able chemiſt, this earth e property of combining with this acid in very unequal pro- ons, that is to ſay, either in ſo ſmall a quantity that the ſalt ing from the combination ſhall have a ſmall exceſs of acid, in h caſe this ſalt is *alum*, or that a compleat ſaturation ſhould take or even more, and then a vitriolic ſalt will be formed with an y baſis, which approaches to a ſelenites with a baſis of calca- earth, by its inſipidity and little ſolubility, but which having s baſis a vitrifiable earth ought to be diſtinguiſhed from the by the name of *ſelenites with baſis of vitrifiable earth*; ſo that clay is nothing but alum ſaturated or ſuperſaturated with its , in a word, a ſelenites with baſis of vitrifiable earth.

e proofs on which M. *Baumè* eſtabliſhes this opinion, are, hat he has been able to reduce alum to a kind of ſelenites by ining in this ſalt the greateſt poſſible quantity of its own earth. hat by boiling clays in diſtilled water, he has always remarked this water diſſolved a ſalt with earthy baſis, of the ſame nature um ſaturated with its earth, which ſalt was decompoſed by ad- fixed alkali, and the precipitate thereby formed was ſimilar to of alum. 3. Laſtly, M. *Beaumè* having obſerved that all decompoſe nitre, that this property is retained even by thoſe which have been expoſed to violent fire, ſuch as that which s into the compoſition of India porcelain; and alſo that vitri- d tartar may be obtained from the reſiduum of the decompo- of nitre by clays crude or baked, concludes, that vitriolic acid e of the conſtituent parts of clay.

appears in fact, that in moſt native clays, there is a certain tity of vitriolic acid intimately combined with it and in ſome ure ſuperſaturated with earth, and this acid adheres ſtrongly eſe earths. But is this obſervation ſufficient to eſtabliſh ſolidly general theory, which we have mentioned, concerning the con- ent parts of clay. I cannot be convinced of it, notwithſtand- all the deference which I am diſpoſed to have for M. *Beaumè*'s ions: Firſt, becauſe it has not been proved, that *all* clays do ain vitriolic acid, ſince for this purpoſe it would be neceſſary ave examined them all, which has not been done, nor is poſſi- to be done on account of the infinite variety of theſe earths. even probable that clays might be found entirely free from vi- ic acid, as the great quantity of this acid was obſerved to vary

much in the clays examined by M. *Beaumè*. If Nature has tributed this acid so unequally, is it not possible that to some she have given none? Secondly, if the vitriolic acid were an essen constituent part of clays, they ought to change their nature m and more as they are deprived of more of this principle; and las should cease to be clays, when they have been entirely deprive it. This however does not happen. For clays exhausted by many washings in ever so much pure water of every thing saline selenitic, so far from losing any of the argillaceous properties, p serve them all, and on the contrary, become more binding more pure; and on the other side, by adding the proper quan of vitriolic acid to the earth of alum, this earth ought to be rende perfectly similar to native clays, but this too does not happen. the earth of alum, deprived of all acid, possesses all the argillace properties in the highest degree, but it loses these properties in p portion as it is recombined with vitriolic acid; it especially lo the characteristic property of clay, and by which it is distinguis from the earth called vitrifiable, namely its peculiar ductility, M. *Beaumè* himself proves from his own experiments.

Lastly, the decomposition of nitre by clays, and the vitriola tartar which may be obtained from the residuum of this decom sition, would prove the presence of vitriolic acid in clays, if t were the only earth capable of effecting this decomposition, and the quantity of vitriolated tartar remaining in the residuum w proportionable to that of the nitre and clay employed. But M. *Veillard* found from very exact experiments, related in a Mem presented to the Academy of Sciences, that the purest sand procu the decomposition of nitre, as well as clays, and that no vitriola tartar results from this decomposition. It is not therefore surpris that bruised Indian porcelain, mixed and distilled with nitre, sho occasion the decomposition of this salt. And although the vitric acid, which is found in many clays, must undoubtedly contribu considerably to the decomposition of nitre when such clays are e ployed, it does not thence follow that this acid should be one of constituent parts of clay in general.

All these considerations incline me to believe that vitriolic a not only is not a constituent part of clay, but also that the a which is found in many of these earths, however it may be combin is only accidental; that it is a heterogeneous matter, as foreign clay properly so called, as calcareous earth, gypsum, spar, quar sand, bituminous, sulphureous and metallic matters, or any oth substances that are mixed naturally in a greater or less quantity almost all clays, and which nobody has ever thought of confideri as constituent parts of pure and simple clay.

M. *Beaumè*, while he thus extended his researches on clay could not fail of forming a theory on the cause of the great fusil

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erved in the mixtures of these earths with calcareous earths, gypsums and selenites; a singular phenomenon which Mr. t discovered, and which M. *Beaumé* and I have had occasion ve upon many different occasions in a very numerous course riments which we made concerning mixtures for making n. I had begun these experiments singly, for which I had ted the muffle-furnace capable of producing the most violent which I have given a description in my memoir on clays, he memoirs of the Academy for the year 1758. M. *Beaumé*, merit I knew, having signified his wish to partake of this ccepted his offer gratefully. The course of experiments had undertaken, was continued with renewed zeal during years, in my laboratory and at my expence. We repeated l the experiments of Mr. *Pott's Lithogeognosia*, and many M. *Beaumé* has also since that time made many interesting ents on clays, an account of which he has published in his upon these earths, and in his book on Chemistry. All periments serve as a basis to the explanation which he has the fusibility of mixtures of argillaceous and calcareous M. *Beaumé* attributes this fusibility to three causes, 1. to olic acid which he believes to be a principle of clays. 2. to l alkali, which according to his opinion, is produced by the f fire in calcareous earths; and 3. to a principle of fusibility, ature is not well known.

idea not being proposed as a doctrine that is proved, I shall discuss the reasons for and against. I shall only say that li which is supposed to be formed in calcareous earth, and vitriolic acid of clays or of gypsum, do not seem to be procure, at least jointly, the fusibility, because these two cannot fail in combining together and forming vitriolated which is not a vitrescent salt. I refer to my Memoir on what I have said on this subject.

result of the experiments which are related in that Memoir thers which I have made since, is that the argillaceous earth , when perfectly deprived of vitriolic acid, is as refractory vitrifiable earth, and even resists more than this latter earth on of saline and metallic fluxes; that the mixture of vitrifi- l argillaceous earths is not more fusible than they are se- ; that pure calcareous earths and gypsums, although very to melt, are nevertheless more fusible, without addition or , than argillaceous and vitrifiable earths; that gypsum is a ore fusible than calcareous earth; that the mixture of a little th calcareous earth or with gypsum, disposes them a little fusion; that pure argillaceous earth in whatever proportion ixed with calcareous earth or with gypsum, does not en- their fusibility; but that by mixing together these three

kinds of earths, namely the argillaceous, vitrifiable and the calc
ous, which do not melt singly nor any two of them united,
greatest degree of fusibility is acquired, of which remarkable ph
menon I do not attempt to assign any cause; but it seems to fu
me with an additional argument for not confounding pure arg
ceous earth with that which is commonly called *vitrifiable*.

*Addition to the article* COMBUSTION *of the former Editio*

COMBUSTION. It is a curious and important question
the contact of air is necessary to combustion. But from
of a sufficient number of facts, this is one of those points in N
ral Philosophy, on which we can only form conjectures. As
then only I propose the following ideas.

It is known that if any combustible body be burnt under a
ceiver containing a certain quantity of air, which cannot be re
ed, this body burns at first as if it were placed in open air.
that presently its flame becomes smaller and less luminous; th
length, sooner or later, according to the size of the receiver,
combustion ceases entirely.

If we afterwards examine the state of the receiver, we shall
that the quantity of air which it contained before combustion
been remarkably diminished by this operation, so that the rece
is in this respect in the same state, as if a part of the air had
exhausted. This first fact proves either that a part of air is des
ed by combustion, or combines with some of the principles o
combustible body. But if we examine further the air in whi
body has burnt and has become extinct, we find that not onl
quantity is diminished, but also that its nature is changed
many respects, and particularly in this, that it cannot again
for combustion, even when it is condensed in a smaller receiver;
from this second fact it follows, that combustion does either
some substance combine with air, which changes the properti
this fluid, or that atmospherical air is a mixture of several
stances, of which only one is fit to maintain combustion, and
this one is absorbed or destroyed in this operation.

These facts are not sufficient to enable us to decide what ch
happens to the air in combustion, and we must therefore rec
analogy. In considering combustible bodies as compound
which the matter of fire is one of the constituent parts, and
combustion as a decomposition in which this igneous princi
separated, it is natural to compare combustion with other de
positions, with which Chemistry has made us acquainted. But
certain that heat alone is capable of separating the principl
many mixts; and there are others, on which heat is not capab
producing this effect, and which never would have been de

po

l, if we had not discovered that the action of certain substances able of effecting or rather compleating what heat alone could o. Several neutral salts, and especially common salt, cannot composed by the sole action of heat, and we should not have n either the acid or the alkali of this salt, if we had not dis- ed by experience, that the vitriolic and nitrous acid were ca- of separating these two constituent parts, by uniting with one m, and thereby disengaging the other.

ese things being considered, may we not conjecture that com- le bodies are of the number of those mixts whose principles t be separated by heat alone, and that the matter of fire par- ly, which is the cause of their inflammability, adheres so ly to them, that it cannot be separated without the assistance ntermediate substance, the action of which united with heat, es capable of procuring that separation; and in this case, is probable, that the air is merely the intermediate substance ed, and as such is necessary to promote combustion? This ation at least appears to agree well enough with all the known mena of combustion, and especially with the principal and nental fact, namely, that no combustible body can really that is, be decomposed by the separation of its inflammable ple in very close vessels and without the immediate contact and that the more considerable and intimate this contact is, ore quickly and vigorously the combustion is effected, as ex- ce shews.

the second place, we may easily conceive that if air acts in stion, as a decomposing intermediate substance, it must sub- itself in the place of the matter of fire, which is thereby dis- ed from its combination; and it is for this reason that there is a considerable absorption, or diminution in a given quan- f air that has served for combustion.

why after a body has burnt a certain time, and has sponta- y become extinct in a quantity of air not renewed, does there n a considerable quantity of an aerial substance which cannot again for combustion? The answer to this question is, that urest air is the only intermediate substance which can serve mbustion, and that the air of the atmosphere is a mixture of air and of another substance, which, notwithstanding it has ppearances and some other properties of air, is nevertheless different. This substance is the gas which has been common- led *fixed air*. But in combustion, it is only the part of the pherical fluid which is pure air that is absorbed and combi- as the decomposing intermediate substance; and therefore, her part, or gas, which cannot act as an intermediate sub- , remains entire after the combustion. If this be the case, a body is burnt in air perfectly pure, no gas ought to remain

after the combuſtion, and I believe this would accordingly happe but we cannot ſpeak with certainty on this point till many impo tant experiments have been made, which have not yet been a tempted, becauſe no method was known till lately of having much purer than that of the atmoſphere, and becauſe the idea theſe experiments could not be ſuggeſted before the late diſcover on the different kinds of gas. Of theſe I ſhall relate one of t fineſt which I have ſeen exhibited by M. *Lavoiſier*, after l *Prieſtley*, in preſence of ſeveral very intelligent perſons.†

It appeared from the experiments of Meſſrs. *Hales*, *Prieſt* *Lavoiſier*; and *Bayen*, that *metallic calxes* contain a great deal of aerial ſubſtance, which is diſengaged during their reduction t metallic ſtate, and that this ſubſtance is the mephytic gas, in pable of ſupporting the life of animals, or combuſtion, when reduction was effected by means of inflammable matter: But m cury calcined without addition, called *precipitate per ſe*, and e *minium* and *red precipitate*, being capable of reſuming their meta form without addition, and as this reduction does nevertheleſs y a large quantity of aerial matter, it was very important to find what this aerial matter was, and eſpecially whether it differed f the gas which is diſengaged in reductions of calxes made by me of combuſtible bodies, and this was the object of M. *Lavoiſ* experiment, which proved that the aerial ſubſtance diſengaged f calcined mercury, when it reſumes its form of running merc without the addition of any phlogiſtic matter, not only is not phytic gas, but is even the pureſt air that can be found, an particularly free from any mixture of mephytic gas. But in o to aſcertain this latter fact, it would be neceſſary to carry the periment further, by making an inflammable body burn in pure air ſeparated from calcined mercury, till this body beco extinct. It would certainly burn much longer than in an e bulk of atmoſpherical air; but if this combuſtion had abſorbed whole of the air, and if none of this gas remained or but very tle of it, this would throw a great probability on the opinion wh I have propoſed. It would then remain to diſcover what is part of the atmoſpherical air, or this gas which cannot ſerv combuſtion.

Dr. *Prieſtley* who has made us acquainted with many of its perties by very ingenious and accurate experiments, ſeems incl to conſider it as a compound of pure air and phlogiſton. But opinion is ſubject to great difficulties and cannot be confirme refuted but by new experiments which remain to be made.

We will here recapitulate the manner in which I conceive combuſtion is executed.

† The Duke *de la Rochefoucault*, M. *Tradaine*, M. *de Merveau*, the D *Ayens*, and the Duke de *Chaulnes*.

I confider every combuftible body as a compound in which or the material fubftance of fire, is combined as one of the iples or conftituent parts of this compound.

I fuppofe, from facts, that this matter of light, this principle mbuftibility of combuftible bodies, cannot be difengaged by nere force of heat, and without the concurrence of the action lecompofing intermediate fubftance,

I again fuppofe, from facts alfo, that there is in nature only kind of matter, which can ferve as an intermediate fubftance he difengaging of the light combined in combuftible bodies, hat this only matter is pure air.

admitting thefe fuppofitions which appear to me perfectly ftent with all the phenomena of combuftion, I believe that we eafily conceive:

Why any combuftible body cannot burn without accefs of and the eafier this accefs is, the more vivid and rapid is the uftion.

Why a given quantity of air can only ferve for the com- on of a given quantity of combuftible matter.

Why in all combuftions, fome air is abforbed and difap- , in a quantity proportionable to that of the combuftible which burns.

Why, when the combuftion is excited in clofe veffels, by means e included atmofpherical fluid, there remains after the body has d to burn, for want of a renewal of frefh air, a confiderable tity of a fluid having the appearance, the tranfparency, the city of air, and which is yet not air, at leaft not pure air, but a which kills animals; which precipitates the quicklime of lime- r, into a mild effervefcent calcareous earth, which faturates ic alkalies, and renders them cryftallifable and effervefcent, &c.

Why the afhes and the alkalies which remain after a fimple buftion are very effervefcent with acids, and yield much gas, *Hales* has fhewn.

Why the calxes of metals are of greater abfolute weight, the metal was before its combuftion; and why in the reduc- of thefe metallic calxes, by which they are deprived of this fs of weight, there is a quantity difengaged either of very e air, or air rendered impure, which has acquired the qualities nephytic gas, according as this reduction is made, either with ithout addition of a new quantity of inflammable matter.

Laftly, why metals, which after having fuffered the action cids, are in a ftate fimilar to thofe which have been calcined nere combuftion, prefent the fame phenomena in their reduc- ; and particularly why mercury diffolved and calcined by ous acid, when it is again reduced into fluid quickfilver in clofe els, yields a great quantity of very pure air, while the laft portions,

portions of nitrous acid that are obtained by diſtillation in the pneumato-chemical apparatus, is ſo altered, that it is only a gas which cannot reſume the properties of nitrous acid, till it be recombined with pure air, with a given quantity of which, it unites to the point of ſaturation.

However important this theory of combuſtion may be, I ſhould lengthen too much this article by the explanations of theſe queſtions. They will occur to the reader after he has attentively examined the articles *Calcination*, *Metallic Calxes*, *Fire*, *Phlogiſton* and *Gas*.

*Addition to the Article* DETONATION *of the former Edition.*

DETONATION. *Stahl* does not only attribute the detonation of nitre to the water contained in it, but he goes farther, and is of opinion that the aggregation of the water is thus entirely broken, and that its particles acquire the properties of air. This is one of theſe ideas, the impoſſibility of which is not demonſtrated. But it appears more probable, that air is itſelf one of the principles of the nitrous acid; and if this be the caſe, it is much eaſier to conceive why this acid has leſs occaſion than any other combuſtible body, of the acceſs of air to effect its combuſtion; ſince it contains a matter which is gradually diſengaged from it while it burns, which has the property of maintaining combuſtion. The flame of nitre which is made to detonate ſlowly for the ſake of obſerving it, ſeems to prove what we have advanced. For it has the appearance of a body, whoſe combuſtion is excited by a violent blaſt, which ſeems to iſſue from within itſelf.

Since the properties of gaſes have been obſerved, ſeveral philoſophers have thought that the violence of the exploſion of gunpowder might be produced, neither by the expanſion of air, nor of the watery principle of the nitrous acid, reduced into vapours during the inflammation and decompoſition of this acid, but to the diſengagement of a conſiderable quantity of a gas which is produced by the effect of the reciprocal decompoſition of the nitrous acid, and inflammable matters with which it detonates. This is the opinion of the author of the notes of the *Engliſh* edition of the Dictionary of Chemiſtry; and certainly this opinion is not without probability. It is further ſhewn by the experiments of Meſſrs. *Prieſtley* and *Lavoiſier*, and others who have lately attended to this ſubject, that the nitrous acid is filled with elaſtic aerial fluids, one part of which may be ſeparated in form of pure air, and the other in the ſtate of a gas, which has no reſemblance to nitrous acid; but which has the remarkable property of being converted into nitrous acid, by mixture with pure air. Theſe

phenomena

enomena which begin to throw much light on the nature of the rous acid, and perhaps of other acids, seem to prove that air one of the constituent parts of the nitrous acid, and it must confessed, that all the other properties of this acid are conmable to this proposition, *See* GAS.

FECULES *of* PLANTS. The name of fecule may be given erally to all matters separated or deposited from the expressed ces of plants, or from the water in which plants are infused. e fecules are hitherto but little known, and it is only very late- that they have been examined. All *flours* and *starches* may considered as fecules. At the article *farina*, an account is given the researches made on that subject.

The green part of almost all plants forms another kind of fecule. is found commonly divided and distributed in the expressed ces of plants, renders them green and turbid till they have been ified; which shews that it is not dissolved, but only suspended, accordingly it is easily separated by clarification, deposition, or filtration. This green part of most plants, although it may be arated in form of a fecule, like starches, does nevertheless er essentially from these, in this respect, that it is perfectly inble in water, even with a boiling heat. It appears from a e printed by M. *Rouelle* in the *Journal de Medecine*, (*March*, 3.) that his late brother was the first who began to examine green matter almost universally diffused through the whole veable kingdom. The property which it has of being insoluble vater, and of being soluble in spirit of wine, ether, or oils, had le the late M. *Rouelle* conclude, that it was of a resinous na-e, and this conclusion is in some measure just. But M. *Rouelle*, younger has discovered, that the whole of the green fecule, ich is separated from plants, is not a pure resin, but that it tains another matter very different, as it yields by distillation retort, the same principles as animal substances do, namely, atile alkali and fetid oil, which principles are not obtained from proper resin.

This substance of the green fecules, which is in some measure nimal nature, not being soluble in water, even with the assiste of heat, appears to be very similar to the glutinous part of na. This is the opinion of M. *Rouelle*, and is very probable. is discovery deserves to be prosecuted, and without doubt, it l with all the requisite care, as it cannot be in better hands n in those of M. *Rouelle*.

The green colour of plants is easily altered, and is changed to a lowish brown, by a kind of fermentation which happens to nts, after they have been gathered, unless this fermentation be vented by a quick drying. I shall observe upon this subject, t although this green colour changes and even entirely disappears,

pears, it is nevertheless not destroyed; and one may, by mean of menstruums, separate and extract the green part of dried plant which have not the least appearance left of their green colou At least, when I examined several kinds of tobacco with Messr *Cadet*, *Demoret*, and *Mitouard*, it happened, that upon applyin ether to some tobacco, which we had exhausted as much as w could by means of water, and which had the usual yellow-brow colour, a very fine green tincture was thereby extracted.

It is probable, that there is in the vegetable kingdom, and eve in the animal kingdom, other kinds of feculent matters; perha even there may be many such. It would be an interesting subje for examination. Most of the colouring parts of the dying m terials, may be nothing but fecules. Thus, for instance, indigo a blue fecule. It differs however from the green fecules of plant not only in its colour, but also in being insoluble by spirituous a oily solvents, and in being only soluble by saline substances, by a kind of putrid fermentation. We may easily perceive th this is a new subject of researches. Every vegetable or animal whole in the order of beings; but this whole is an admirable a semblage of a great many mixts, very heterogeneous, and of di ferent orders. To separate these from each other, and to discov the nature and properties of each, is the object of chemistry.

FARINA, or FLOUR, is a substance which has much of t nature of gum or mucilage, but which has evidently more tast is more susceptible of fermentation, and of yielding nourishment.

This matter abounds in the vegetable kingdom, and is the distributed in different parts of certain vegetables. Some kin of roots, such as those of briony, potatoes, that from which cassa is extracted, salep, and several others contain a great deal of white fecule, which has the properties of farina. But the larg quantity of this matter so valuable, on account of its supplying t principal nourishment to mankind, and to many other animal resides in grains, which are therefore called farinaceous, such those of wheat, rye, barley, oats, rice, and other similar plant It is deposited in these grains for the same purpose, as mucila and sweet oil are in the seeds called *emulsive*, that is, to serve f the nourishment and growth of the germ of the plant, in the fir period of its expanding. It is a nourishment ready prepared, and it be may said, already digested by the parent plant, for the suppo of the beings which it re-produces. It is the aliment of the earliest age, while they are yet too weak to extract directly fro the earth and other elements, the materials which they must a terwards transform by their organic action into their own sub stance; in the same manner as the emulsive milky matter of man other seeds, that of the yoke of an egg, and lastly, the milk o animals, are evidently destined to procure to the embryos, o

youn

ng of these several beings, a nourishment already half assimila-
, the digestion of which is easy and proportionable to the
kness of their organs.

As soon as granivorous animals arrive at an age, when they are
to go in quest of food, they search for by instinct the farina-
s grains, which they prefer to every other vegetable aliments.
n man, although he can be nourished by almost all vegetables
animals, has discovered from time immemorial, in these grains
liment suited to his nature, and preferable to many others.
haps he began by bruising these grains between his teeth, and
sing those only which grew spontaneously on the surface of
earth. But the intellectual faculties which distinguish him
other animals, must soon have taught him to multiply this
ious aliment, by cultivation, to break the farinaceous grains
een stones, in order to separate from it the farina or flour,
lastly to give to this nutritive part certain preparations which
er it more palatable, and more easily digestible. This is cer-
, that from the earliest ages of the world, men have cultivated
farinaceous plants and have prepared the flour which they
ce extracted for their principal aliment.

ut it must appear surprising, that it is only within a few years
the nature and principles of a substance so useful to us have
investigated. Mr. *Beccari* in *Italy*, and Mr. *Kessel Meyer* in
*many* appear to have been the first who have made experiments,
rder to discover the constituent parts of flour. Their labours
not been unsuccessful. To them we owe the discovery of a
tance before unknown, whose properties are very curious,
idered in a chemical light, and very interesting by the influ-
which they must have on the qualities of bread. Another
ntage also very great of these first researches, is, that they
excited the attention of several excellent chemists, who, after
ating the experiments of Messrs. *Beccari* and *Kessel Meyer*, have
ed them, and will undoubtedly yet carry them farther.

our diluted and diffused, in cold water, renders this liquid
e and milky, without being really dissolved in it. If a cer-
degree of heat be given to this water, then the flour is actually
lved in it: the opake whiteness disappears, and the liquor be-
es a transparent paste, and approaching at once to the nature
mucilage and a jelly so much thicker, as the quantity of flour
loyed has been greater. This kind of paste may be dried by
orating the water, and thus becomes a semi-transparent mat-
brittle when it is thin, but which has nearly the consistence of
gum when it is in thicker masses. This dried paste may be
ned, diluted, and even re-dissolved in water as gums are, but
a little more difficulty and less completely.

When

When the ſolution, or even the mere dilution of flour in water, is not quickly dried, a fermentation evidently appears to take place in it, which is at firſt of the ſpirituous kind, if the viſcidity of the farina has been deſtroyed previouſly by the preparation, which farinaceous grains are made to undergo, before they are employed in the making of beer. But this ſpirituous fermentation is inconſiderable, and paſſes at once to the acid fermentation, and from thence to mouldineſs, to a kind of putridity, if the farinaceous matter has all its viſcidity, as we ſee for inſtance in paſte, which ſoon ſuffers theſe alterations when a quick drying, or great cold do not preſerve them.

When flour is diluted with a much ſmaller quantity of water, it forms a ductile paſte, which may be kneaded: And when it is expoſed to a baking heat, it forms what is called a cake. By means of this preparation, the flour acquires a more agreeable taſte, eſpecially in the cruſt of the cake, becauſe this cruſt is dryed by the fire, and even ſcorched, by which its taſte is conſiderably heightened. As to the internal part or crum of this cake, it is obſerved to be ſmooth, compact, more tranſparent than the paſte was before it was baked; in a word, it is a very thick flour-paſte, very heavy, inſipid, not eaſily diluted by the ſpittle, nor digeſted by the ſtomach.

But when the paſte, before it is baked, is allowed to undergo to a certain degree the ſpirituoſo-acid fermentation, of which it is ſuſceptible, or which may be haſtened by mixing with it ſome leaven, then the paſte ſwells by the diſengaging of the volatile gas, which riſes in the fermentation, the viſcidity is diminiſhed, by the inteſtine motion and conſequent diviſion of the particles. When the paſte, as ſoon as it comes to this ſtate, is baked, it becomes bread, the crum of which, inſtead of being compact, heavy, and inſipid, like that of the unfermented cake, is light, porous, of a more agreeable taſte, and more eaſily digeſtible. This is undoubtedly the beſt and moſt wholſome ſtate to which farinaceous grains can be brought, for the purpoſes of digeſtion and nutriment.

Theſe properties of flour have been ſo well and ſo long known, that it would have been uſeleſs to have mentioned them, if it was not neceſſary to have them now preſent in our minds, that we may connect them properly with the diſcoveries which have been lately made, concerning the conſtituent parts of flour. I ſhall only obſerve further, that if we add to the above ſome other facts, which were known by chemiſts, namely, that flour was no more ſoluble than gums in ſpirit of wine, or oils, and that when expoſed to diſtillation with a degree of heat, ſuperior to that of boiling water, by which alone, they as well as other vegetable matters, not of the volatile kind, can be decompoſed, they yield the ſame

principles

ciples as all the other bodies do, which are susceptible of the tuous fermentation; it was natural to think, that this sub-e was known nearly as well as it could be. But this matter, h was supposed to be homogeneous, is really not so; and it separating and distinguishing a substance quite different from white feculent part, which predominates in flour, that the ern discovery consists.

is easy to conceive that this substance, different from the ous and feculent matter called *Starch*, but which is in its na-l state intimately mixed with this starch, and which was not eptible in any of the known operations, for the reasons here-mentioned, could not be distinguished and separated from it by some operations of another nature; and this accordingly what happened.

cannot say whether Mr. *Beccari* was the first who thought of ing with cold water, paste made of wheat flour, which was re-, and had not undergone either fermentation or baking, and ontinuing this washing by frequent changes of water, and col-ng each time the remains of the paste, till the water, from g white at first became clear and limpid, and till the remain-part of the paste can be observed to be quite a different substance n the other part or starch, which the water had diluted and ied off. I am inclined to believe that this practice was not rely unknown, and was used by some artists to procure a paste, glue more solid than the common one made of starch, fit for erent purposes, such as the joining together pieces of broken celain; but this appears certain, that if this matter was thus wn before Mr. *Beccari*, those who used it, considered it only he strongest and most adhesive part of the flour, and did not pect it to be of a nature essentially different. He was, therefore, first who excited the attention of chemists upon this matter, publishing in the Bolognian Memoirs, a course of experiments le to discover the nature of this substance.

ometime afterwards Mr. *Kessel-Meyer* made it the subject of a sis, held in the University of Strasbourg; and then several er chemists made it the object of their researches. These re-rches could not fail in procuring an analysis of flour, much more urate than had been made before. Mr. *Rouelle* is one of the t who engaged in this matter, with much zeal. I ought here give testimony, that from the year 1770, he gave in his course chemistry, the analysis of corn, from the experiments of Messrs. *ccari* and *Kessel-Meyer*. I saw there, together with all our audi-s, the different products of the analysis of corn made by Mr. *uelle*, and particularly a large quantity of the glutinous matter, ferent from the starch. Messrs. *Beaumè*, *Malouin*, and *Parmentier*, ve also mentioned it in their works. Lastly, Mr. —— Author of

of the French edition of the London Pharmocopeia, has fince
ſumed this matter, and has done me the honour to invite me to
operate with him in the numerous experiments, which he
undertaken, in order to verify thoſe which have already been ma
and to add many new ones. An account of theſe will be give
his third and laſt volume of the London Pharmocopeia.

Whatever therefore I ſhall ſay concerning the late analyſe
flour is from the above-mentioned chemiſts, eſpecially the Aut
of the tranſlation of the London Pharmocopeia, who has b
pleaſed to allow me to anticipate his account of his new reſearc

When paſte made with wheat flour is waſhed in the manne
Mr. *Beccari*, before it has been fermented or baked, the part wh
remains, after the water can extract no more ſtarch from it,
called the *gluten*, or *vegeto-animal matter*.

The quantity that is obtained of this matter varies much,
this difference proceeds probably from the qualities which the fl
receives from the kind of corn whence it is prepared, and fr
thoſe which it receives from the ſoil and ſtate of the atmoſph
having been more or leſs favourable to the vegetation of the co
This quantity extends from a fifth to a third of the whole,
even more, according to Mr. *Beccari*; but its qualities are alw
the ſame, whether its quantity be greater or leſs.

The manner of obtaining this matter pure and ſeparate fr
ſtarch, ſhews that it is not ſoluble, nor even diffuſible in water,
its great tenacity and ductility ſhew that its parts have the p
perty of joining and adhering well together. Thus it forms a n
which has nearly the ſame ſoftneſs as the paſte whence it is p
pared; its colour is a little more grey, and it is much more tenaci
and elaſtic; ſo that it may be extended till it becomes ten
twelve times longer without breaking, and when one ceaſes
ſtretch it, it contracts to nearly its former dimenſions. It may
alſo extended in breadth, and when thus made thin, it has a ſmo
ſurface, and reſembles much in appearance the membranace
parts of animals, ſuch as the cellular membrane, and the epiplo
Its ſmell, when it is freſh, is exactly the ſame as that which is p
ceived in Corn-Mills. In taſte, it is inſipid, and it cannot be dilu
in any degree in the ſaliva by means of maſtication. In order to p
ſerve its ſoftneſs and its extenſibility, it muſt be kept in water.
adheres ſo ſtrongly to all dry matters, that in order to manage
to mould it, we muſt frequently moiſten our hands with water.

This glutinous matter dries very eaſily. And when it is ma
to dry quickly, all fermentation is prevented. It becomes m
brown when it is dried, and acquires the ſemi-tranſparency
glue, and nearly the ſame ſolidity. When bent to a certain degr
it breaks with a ſmooth ſurface and with noiſe. Theſe qualit
make it fit to ſerve as a glue to faſten pieces of glaſs, porcelain, wo

ven of metal. When it is to be used for this purpose, the s to which it is to be applied must be very dry. It then is made to adhere to them, and when dry, it is unalterable by thing but the liquors that are capable of dissolving it. Water er, although it cannot dissolve it, reduces it in time to its al soft state.

en it is dried by as strong heat as it can bear without being posed, such as that of an oven heated to bake small pieces of , it swells extremely, so as to occupy fifteen or twenty times rmer bulk, and this expansion is caused by aerial or other rs, which are rarified within it, and form many large cavities. is kind of baking it acquires a little more taste and smell, however, proceed only from the crust being scorched. It hen eatable, but is tough like leather, and more incapable g diluted by the spittle than before it was baked.

his glutinous matter be boiled in water, instead of being put oven, it undergoes a kind of coction, without any swelling, ires a little more solidity, loses almost all its tenacity, its ex- lity, its gluey quality, retains only about as much elasticity as room, and does not become less insipid or more eatable than it efore. The water of the decoction evaporated to dryness no residuum different from that of pure water.

en this glutinous substance is burnt in open air, or distilled tort, it exhibits the same effects and the same products as s purely animal, and not at all like vegetable substances. a piece of this dried glutinous matter is put into the flame ndle, it crackles, becomes black, swells, liquefies in some de- nd flames like a feather, or like a piece of horn, or glue, a disagreeable empyreumatic smell exhales like that of burn- imal substances. By distillation in a retort, a volatile salt irit is obtained and a fetid empyreumatic oil, which has all operties of animal oil. Lastly, the coal which is left, either he combustion or after the distillation, does not differ in any from animal coal. It is not more combustible, nor more e of furnishing fixed alkali by incineration, than the coal of l substances.

e animal character of this glutinous part of flour, is completely inted in the effects of fermentation when it is kept soft, some time longer or shorter, according to the temperature of ; and especially when it has not been perfectly freed from rch, as M. *Beaumè* justly remarks, it acquires the smell and f old Dutch Cheese. I have seen and eaten some of this s of Cheese which Mr. *Roucelle* had prepared, and which he ted at one of our courses in the King's Garden. It resem- exactly the cheese of milk, that if it had been salted, a per- ight easily have been deceived by it. But it appears that it

 is

is to ſome remains of ſtarch that this quality is owing; for w the glutinous ſubſtance is perfectly freed from ſtarch, and kept der water in a warm place, it undergoes the putrid fermenta and acquires a fetid cadaverous ſmell. It is therefore prob: that the mixture of a certain quantity of ſtarch, which tends ſpirituoſo-acid fermentation, ſuſpends and ſtops the progreſs o putrefaction of the gluten, and retains it at leaſt during ſome in the ſtate of imperfect putrefaction of decayed cheeſe. We obſerve that when the gluten comes to this ſtate of cheeſe, it be diluted by ſaliva and is very eatable; which change is ent produced by fermentation.

We have not been able to diſſolve this gluten, when freſh means of the yolk of an egg, nor by ſugar. Mr. *Keſſel-Meyer* ever, thought that theſe ſubſtances had ſome action upon it. ther oils, nor ſpirit of wine, nor even ether could diſſolve it. S of wine does however ſeparate from it, by digeſtion, a ſmall q tity of a ſubſtance which has the marks of a reſinous oil. R fied ſpirit of wine applied to freſh gluten in a conſiderable qua does not at firſt occaſion much change; but at length, the gl is rendered very hard, probably by a kind of drying. It is obſerved, that the gluten thus hardened and dried by ſpir wine, retains the white opake colour which it has when freſh ſoft, and does not acquire the appearance of glue which it aſſ when dried in open air.

Liquid fixed alkali ſcarcely acts upon gluten when cold, and probably induced Mr. *Keſſel-Meyer* to think that this ſolvent ha power upon it. But by means of boiling, we have ſeen this lution ſucceed very well. The alkaline liquor, after it has upon the gluten was a little turbid, and could not be filtrated out much difficulty and very ſlowly. After the filtration, we rated from this ſolution, by means of an acid, a ſenſible quanti gluten which had been diſſolved; but this gluten did not re its elaſticity.

All the experiments which have been hitherto made by diſſ chemiſts concur in eſtabliſhing that the oily vegetable acid, ſu the cream of tartar and vinegar, are the ſubſtances which beſ ſolve the gluten and produce the leaſt change in it. And in experiments I obſerved, that this ſolution was eaſily effecte vinegar diſtilled or not diſtilled, the liquor being neverthele ways turbid, ſomewhat milky, and incapable of filtration. addition of liquid fixed alkali rendered this ſolution of glute vinegar more turbid and more milky, and the gluten ſepa from it in the form of ſcum. When thus ſeparated, it was f to have its original elaſticity and other characteriſtic properties

When this ſolution of gluten in vinegar is evaporated, gentle heat, without any addition, pellicles inſoluble in wate

gradu

lly ſeparated, and at the bottom is formed a kind of mucila-
gelatinous and gluey matter. During this evaporation, a
ſmell of vinegar was exhaled. As this combination of gluten
negar is turbid, probably part of the gluten is imperfectly
d, and it is alſo probable, that this is the part which ſepa-
form of pellicles during the evaporation, while the part
combined with the acid, is found under the form of the
ginous matter which occupies the bottom.

ecting the action of mineral acids upon the gluten, we
d a difference between our experiments and thoſe of Mr.
*Meyer*. This author ſays, that theſe acids do not diſſolve
ten; whereas we obſerved, that the three mineral acids,
centrated ſtate, acted with efficacy upon this matter, whe-
was freſh or dried. The reſult of the repeated experiments
Mr. —— has made upon this ſubject, was, that the nitrous
ed more quickly, and produced more effervescence than the
or marine, that the ſolution in nitrous acid was of a deep
colour; that the ſolution in the vitriolic acid was of a dark
colour; and that the ſolution in the marine acid, was of a
own, with a violet hue. I ſhall not relate here the detail
many intereſting experiments which Mr. —— has made
eſe combinations of mineral acids with gluten, but ſhall
at to himſelf to communicate. I ſhall only obſerve, that
eſe experiments, there is reaſon to believe, that when the
rated mineral acids diſſolve the gluten, they decompoſe at
part of it. This conjecture is confirmed by the obſervation,
theſe combinations, a certain quantity of an oily ſubſtance
ays ſeparated, which had the ſmell and conſiſtence of fat
t had been expoſed to the action of mineral acids; and alſo
er many ſolutions in water, or in ſpirit of wine, filtrations,
ns, and evaporations in open air, many of which were
ed during ſome years, Mr. —— obtained at laſt, without
p of fire, from the nitrous ſolution, a nitrous ammoniacal
d from the ſolution in marine acid, a marine ammoniacal
f the exiſtence and nature of which ammoniacal ſalts we
ourſelves by the moſt deciſive proofs, ſome of which were
n company with Meſſrs. *D'Arcet* and *Rouelle*. From theſe
nents, we learn this important piece of knowledge, that,
gh by the application of fixed alkali to freſh gluten, we
ot ſenſible of any diſengagement of volatile alkali, it is ne-
eſs certain, that this volatile alkali does exiſt ready formed
gluten, and ought to be conſidered as one of its conſtituent
Is it not the ſame caſe with the volatile alkali which is
d by diſtillation, or by putrefaction from animal matters,
hich the glutinous part of flour has, as we have ſeen, ſo
a reſemblance? This can be known only by a ſeries of ex-

 periments,

periments, ſimilar to thoſe which Mr. —— has ma
gluten, and which he has begun to make on animal n
preſent we ſhall confine ourſelves to the new analyſis o
ſhall proceed to relate what has been diſcovered concer
ture and properties of its other parts, of which the m
able is the white mucilaginous ſecule, known under
of *ſtarch*.

We have ſeen, that in order to obtain the glutinous
neceſſary to waſh in much water, the crude and recent pa
This waſhing ſeparates from it the ſtarch which is diſ
ſuſpended in cold water, without being diſſolved in
that reaſon gives to the water a white opake milky
while it remains thus ſuſpended. But as it is ſpecific
than water, it gradually ſubſides, and forms a whi
which is *ſtarch*. But it is very neceſſary to remark, th
—— has aſcertained by experiments, this ſtarch whi
before any fermentation has happened, is greyiſh,
wants that gloſſy whiteneſs of the ſtarch that is ſold by
facturers, who allow the liquor to undergo the acid fe
and even ſome degree of putrefaction, before they
ſtarch. After the liquor has thus fermented, the h
which ſubſides firſt, is the whiteſt and beſt ſtarch.
manufacturers ſeparate carefully the upper part of th
which they ſet aſide as not being fit for ſale. The ſed
to this is the common ſtarch, and that part which is at
of the veſſel is the ſtarch of the beſt quality.

Mr. —— has imitated theſe operations. He left a
water which had been employed to waſh the paſte to
the fermentation which it could. It became very ſou
ſurface a mouldy cruſt was formed, in which were ma
tions of different colours, but particularly of ſever
green. The upper part of the ſediment which was fo
bottom of this liquor was of a dirty grey colour, but
part was very white, and after it had been carefully col
waſhed and dried in open air, it was found to be
white, neither acid nor alkaline, inſipid, not capable
a binding paſte with water, as flour does; in a word
the ſtarch commonly ſold.

It follows from theſe properties of the feculent part
the flour, that independantly of its not being ſoluble
ter, it is not even rendered ſoluble by means of fermen
remains unchanged in a liquor, in which the acid an
mouldy fermentations paſs through their ſeveral degre
follows from theſe experiments, Firſt, That the ferment
the white milky water with which flour-paſte has been
dergoes, is not owing either to the glutinous matter, ſi

water, nor to the ſtarch, ſince it is found to be unchanged
s fermentation. In order to find what ſubſtance cauſed the
ntation, Mr. —— evaporated with a gentle heat, a ſuffi-
quantity of this water with which the waſhings had been per-
d, after it had depoſited its ſediments, and before its fer-
tion had begun; and he obſerved that the reſiduum of this
ration was a matter of a yellowiſh brown colour, viſcid, gluey,
taſte very ſlightly ſaccharine, which in combuſtion and in
tion preſented the ſame products and effects as ſugar does,
hich Mr. —— calls properly a mucoſo-ſaccharine matter.
theſe important facts ſhew ſufficiently the cauſe of the dif-
es obſerved between the different ſediments of ſtarch, and
aſons of the obſervations uſed by the manufacturers of that
odity. For we may eaſily conceive that the ſtarch which
es before the fermentation, draws down along with it a part
mucoſo-ſaccharine matter, which adheres to it by means of
cidity, and depraves its colour; whereas the ſtarch which
ofited after fermentation, by which the mucous ſaccharine
is attenuated and deſtroyed, ought to ſubſide more readily
quor deprived of its viſcidity, and become purer and whiter,
e the colouring heterogeneous matter has loſt that viſcidity,
eans of which it adhered to the ſtarch before fermenta-

reover, as ſtarch is the baſis and predominant part of flour,
very important to know what kind of bread could be made
two kinds of ſtarch which I have mentioned, namely, the
nd white. Accordingly Mr. —— has made this experiment.
aker who was employed in making this bread, obſerved that
ſtarches could not make a binding and tough dough, like
ade with flour, that the dough thus made by ſtarch, could
ly be kneaded, was apt to ſplit, that it was almoſt impoſ-
o form it into cohering loaves, and that notwithſtanding the
of which he added a conſiderable quantity, it did not ſwell
ſo much as the dough of flour does. The quality of theſe
, after they had been baked, was found to be ſuch as might
pected. Their taſte, excepting a little bitterneſs which aroſe
the yeaſt, was not diſagreeable nor very different from that of
ary bread, but the cruſt of theſe loaves was much cracked;
had riſen much leſs, and wanted the lightneſs and ſponginess
dinary bread; but were on the contrary, hard and dry, which
red their maſtication more difficult; and all theſe faults
more conſpicuous in the loaf made with white ſtarch, than in
ade with the grey ſtarch.

hen the beſt ſtarch that is ſold, is expoſed to diſtillation in a
, it yields nothing but an oily, empyreumatic, brown acid

ſpirit, and an empyreumatic oil which is very thick towards the end of the operation.

The difference between the products of ſtarch and of the glutinous matter is, that the latter does only yield the products of ſubſtances perfectly animalized, whereas the ſtarch yields only the principles of vegetable matters. M. *Rouelle* obſerves, that the empyreumatic oil of ſtarch is heavy, while that of the glutinous matter is ſo light, that it ſwims upon the volatile alkaline liquor.

When the entire flour of wheat, or bread made of this flour, was diſtilled, in a retort, by Mr. ——, nothing was obtained, but a ſaline oily ſpirit, which contained an acid and an empyreumatic oil. The volatile alkali of the gluten did not appear in theſe analyſes, becauſe it was combined with the predominant acid of the ſtarch. But by adding to the product of theſe diſtillations, a ſufficient quantity of fixed alkali to ſaturate all the acid, we obtained this volatile alkali by a new diſtillation of the mixture, and it is remarkable, that it appeared to be leſs in quantity in the products of the diſtillation of bread, than of flour.

The reſult of all this inquiry into the nature of flour, is that this matter is not homogeneous, and that it contains three ſubſtances very diſtinct and ſeparable from each other.

The firſt and the moſt abundant is pure ſtarch, or a white fecule, inſoluble in cold water, ſoluble in hot water, and of the nature of mucous ſubſtances, which, when diſſolved, form watery glues. This matter is then ſuſceptible of fermentations, eſpecially thoſe of the acid and mouldy kinds; and it yields, when analyſed, an acid ſpirit, and an heavy empyreumatic acid oil.

The ſecond ſubſtance is the gluten, whoſe properties have been deſcribed, a ſingular matter, which although indiſſoluble in cold water and in hot water, and capable of adhering ſtrongly as reſins do to all bodies that are not wet, has not however any of the other properties of reſins, and other concrete oily ſubſtances, and ſeems to approach to the nature of gums in the reſiſtance it makes to the action of ſpirit of wine, oils, ſaponaceous menſtruums, and ether, as well as by the property which it has to form a glue. But it is not a gum, as appears from its inſolubility in water, and from the principles obtained from it by diſtillation, which are different from thoſe which gums yield. As theſe principles are exactly the ſame as thoſe obtained by analyſing animal ſubſtances, and as the effects of the fermentation, of which it is ſuſceptible, are analogous to thoſe which are produced by animal matters, it is to this kind of compounds that we ought to refer this ſubſtance. Among all animal matters, cheeſe is that to which this glutinous ſubſtance is moſt ſimilar.

Laſtly, the third ſubſtance which is obſerved in flour, is mild, perfectly ſoluble in cold water, of the nature of ſaccharine extractive

ctive mucous matters, and susceptible of the spirituous fermen-
on. This latter substance is found in a small quantity in flour,
east in that of wheat; for it is very possible that a larger quan-
may exist in the flour of other grains.

There can be no doubt but that it is from the union and just propor-
of these three constituent parts of the flour of wheat, that the su-
iority of this flour depends over all others for making bread, that
ight, agreeable, and salutary. For it is proved by the experi-
ts of Mr. ——— on the bread made with starch, that even
flour of wheat yields a very inferior kind of bread, when it has
n deprived of its glutinous matter, and a still worse bread,
en deprived of its mucoso-saccharine part.

t is also certain, that the flour of all the other grains of which
ad not so good as the bread of wheat-flour can be made, either
tains less or none of the gluten; for experiments have shewn,
t by treating these different kinds of flour in the same manner
has been mentioned of wheat-flour, no sensible quantity of
tinous matter can be separated; and these observations seem
demonstrate that it is to this substance of animal nature that the
r of wheat owes its property of making the most excellent
ad.

t has been considered whether this gluten be nutritive, and
e chemists are of opinion that it is not. But this opinion must
e arisen from want of due attention to the nature of this sub-
ce. For since it is perfectly similar to animal matters, why
uld it not be capable of nourishing as well as they It is true,
t when the gluten is pure, and separated from the other parts of
r, and when it has not undergone any fermentation, its glutinous
ality and extreme tenacity would render it a very unhealthy, and
ost indigestible aliment: But the case is otherwise, when it is
ided in infinitely fine parts throughout the whole substance of
flour, and when these parts are separated from each other by
interposition of those of the amilaceous and mucoso-saccharine
stances of the flour. For Mr. ——— found by experiments,
t the glutinous matter is contained in an infinitely less quantity
the bran. This gluten is so soluble in this state of division and
tribution, which is its natural state, that the mere degree of heat
baking, or even the slight fermentation of dough, are sufficient
combine the glutinous with the amilaceous parts of the flour, so that
ey cannot be afterwards separated. When flour is boiled in milk,
in water, in order to make book-binder's paste, the gluten cannot
any longer extracted from it; neither can it be separated from
leavened bread, or even from dough which has but begun to
ment, though not baked, and still more from bread fermented
d baked. Several of these trials have been made by Messrs.
*ccari*, *Kessel-Meyer*, and other chemists. We have repeated all

 of

of them with great care, so that it may be considered
strated truth, that baking and fermentation render th
and mucoso-saccharine parts of flour capable of perfec
its gluten.

Such are the late discoveries which we owe to th
philosophers above-mentioned concerning the constitu
flour. They are certainly very interesting in themselv
they not become much more so, if it were possible to
to an object of so great consequence as bread is? Flou
not the only one, as is well known, of which bread is
the breads of other inferior grains, although perhaps
nourishing as that of wheat, are confessedly not so goo
digestible; and as they are cheaper, they are almost th
our peasants. How great then would be the advantage i
could be meliorated without much additional expence.
any method of effecting this, the knowledge which we
acquired on the nature of flour, and an accurate enqu
the other farinaceous matters, are certainly the most pr
on which we ought to proceed. The gluten of wheat
does not exist, or in very small quantity, in the
is it not the principal cause of the difference in quality
several kinds of bread, for the greater or less whit
essentially affect their properties? On the other side,
tion and nature of gluten are perfectly known. Its
racter being thus ascertained, seems to indicate that a
to it may be substituted at a low price, among anim
such as the caseous part of milk, jellies or glues o
bones, cartilages, tendons, &c. or even certain vegetab
bages, and turneps, which yield by analysis the same
animal matters. How many experiments and resea
yet to be made on this subject?

M. *Parmentier* has particularly applied his attention t
and frequently communicates to the Academy of Sci
fult of his inquiries, which are not unsuccessful. In
of this chemist, which are not yet all published, we
has particularly examined the amilaceous part of flour,
well remarks that this substance, which he justly consi
very nourishing, is much less susceptible of alteration
tion, than the other parts of flour. It is certain, th
makers extract easily from spoilt corn or flour, as g
they could from the best flour. And we are indebted
*mentier* for his endeavours to make useful applications
Without having any knowledge of the experiments of
at which I alluded; Mr. *Parmentier* made similar expe
object of which was to find out what kind of bread m
from starch alone, and then to discover what substan

of giving to this insipid, and heavy bread, the good qualities ich it wants. The experiments of M. *Parmentier* have shewn, hat from potatoes, made into paste with yeast and a little salt, a read may be formed, which he says is excellent, wholesome, ery nourishing, and which in times of scarcity may be substituted or bread of wheat, rye, barley or oats." This is a valuable fact. is of importance to know that with the starch obtained from ilt grains and flour, and which may be preserved very long with- any alteration, it is possible to make a bread light and well- ed. I, and also several other members of the Academy, have of this bread made from starch by M. *Parmentier's* process, and ound it to be sufficiently well raised, and of an agreeable taste at , but afterwards I perceived a bitterness, which it is to be wish- could be removed. The knowledge we have already acquired on nature of wheat-flour, and of its constituent parts, gives room ope that we may be able to carry this bread of starch, and that he inferior grains, to the highest degree of perfection. This wledge is at present so far advanced, that we may consider the blem as already resolved. All the world agrees that the superi- y of bread of wheat-flour is owing to the gluten, the animal nature which is ascertained. Analogous, and equivalent substances, are nd abundantly in the animal kingdom, and even among some etables. Mr. *Parmentier* has already met with a matter in po- es, which in a certain degree may supply the place of the en. But are potatoes the best of all the substitutes that can be nd? We ought not to admit that they are the best, till accu- experiments have been made with other animal and vegetable stances, whose analysis may shew the most perfect resemblance h the glutinous matter of the flour of wheat. The extent of se experiments is undoubtedly great, but the research is highly ortant; for when the best substitute for the gluten is once as- ained, we shall be able to make bread as perfect as that of eat-flour, with all the other kinds of flour.

FIRE. Chemists consider fire, as also the other elements, in very different views: first, as it enters into the composition nany bodies, in which it is a principal or constituent part; and ondly, as being pure, free, not entering into any compound, acting sensibly and strongly upon all natural bodies, and pro- ing effects as a powerful agent in all chemical operations. In latter point of view we shall consider fire in this article. It l be considered as a principle under the article PHLO- STON.

Pure, free, and uncombined fire seems to be a collection of par- es of a very subtle matter; and all the properties of this ele- nt shew that its particles are infinitely small, have no sensible adhesion

adhesion to each other, and that they are continually agitated by a very rapid motion.

From this definition, fire appears to be a body essentially fluid, and many facts concur to prove that it is the only body essentially fluid, consequently the cause of the fluidity of other bodies; and that as it alone counterbalances the general tendency of all the other parts of matter towards each other, it prevents them from uniting into one immense mass, homogeneous, and as hard as matter can be.

It is difficult to conceive this essential fluidity of fire, this incoherence of its integrant parts, and the rapidity or their movements, by which fire is excluded from the class of aggregate substances, and is therefore different from all other kinds of matter. For the parts of all aggregate bodies evidently yield to general gravitation, and unite together with more or less force, whereas the parts of fire seem to avoid each other, and are repelled with the greatest violence.

This mode of existence of fire, which is indicated by all that we know of its effects, and of its properties, cannot be comprehended according to the hypothesis of attraction; unless we suppose, as a well-known geometrician thinks he has found by calculation, that attraction does only act within certain limits of proximity, beyond which it becomes negative, and is changed into repulsion; or by saying, with the Count de *Buffon*, the parts of fire are endowed with much greater elasticity than those of all other bodies, whence it happens, that when they move towards each other, by the attractive force common to all matter, and come into contact, instead of uniting and adhering together, according to the common law, they rebound from each other by means of their perfect elasticity, and are repelled in a contrary direction, and with a force equal to that which Mr. *Buffon* calls expansive force, and which, although it is produced by the attractive force, does nevertheless destroy or rather continually resists the effects of this latter force, and becomes an antagonist necessary to continue the motion of the parts of matter.

These two ideas appear to me to be equally consistent with the nature of fire, and when they establish a force capable of counterbalancing the force, or rather, the direction, of attraction, they may both serve to explain in a satisfactory manner, the great effects which fire does incessantly produce in nature.

The most obvious of these effects, are the exciting in us the sensations of heat and light. From these alone, mankind in general judge of the presence or absence of fire, so that nothing but what heats and gives light, is commonly thought to be fire. But it is necessary that natural philosophy and chemistry should examine the matter a little more profoundly. Unhappily this examination

ation is attended with great difficulties. Of these, the princi-
s, that when we come to examine all the known effects of
and to compare them, we find it difficult to decide whether
heat and light belong to one and the same substance, or to two
nct substances. Strong reasons are alledged for and against
of these opinions. As a very intense light is always accom-
ed with heat, and as a body intensely heated is always lumin-
it might seem that there is but one substance, whose different
es of existence excite in us the sensations of heat and light:
on the other side, these two sensations do not accompany each
r with equal degrees of intensity. Sometimes bodies heated
considerable degree emit no sensible light, while other bodies
uminous, although not hotter than the ambient bodies. For
nce, boiling water is very hot, and yet gives no light:
le the moon, and phosphoric bodies seem to be very lumin-
although they discover no heat. These reasons are strong
gh to make us presume that the two sensations are excited by
distinct matters, dependant however on each other.

ut among the effects of fire in action, there are others, which
y opinion, allow us still less to confound light with heat,
ely, those that shew that they act very differently on bodies.
certain that no bodies are impenetrable to heat, whereas light
trates those only which are known to be transparent, and is
cted more or less completely by all the others. But two beings
h so differently affect certain other bodies, are necessarily
nct, and we shall therefore consider them as different, as seve-
ood philosophers, particularly the Count de *Buffon* have done.
ow that it may be said, that heat and light may be the same
ance differently modified; that fire itself, with all its proper-
is nothing but the mode of existence of any matter; that
, water, air, in a word, all material substances may become
and also that fire may be changed into earth, air, &c. and
thus all the elements are transmutable into each other. The
ssibility of these transmutations cannot indeed be proved, be-
e we want, and always shall want the knowledge necessary to
le of what matter is, or is not susceptible. But the true object
atural philosophy is not to discover what may be, but what
nd we can only consider as existing, those things whose
ence is proved. But, this transmutability of all substances
each other, not only, is not proved, but no fact can be
ced to render it probable. It would therefore be in vain to
der too vague ideas, and I only mention them in this place,
use they every now and then are brought up even in modern
ngs. I return to the ascertained effects of heat and light.

s these effects are different, it follows, as I have said, that heat
ight are not the same thing; but are each of them a substance
existing

exiſting ſeparately and diſtinct not only from each other, but alſo from all other material ſubſtances? this is another queſtion which is not eaſily reſolved, the nature of fire is too little known to give us hopes that we can have clear ideas upon this ſubject. All that we can pretend to do, is to propoſe ſome conjectures from well known and certain facts.

It is to be obſerved, that this latter queſtion does not ſeem to concern light. We cannot really doubt that this being, by means of which we ſee whatever may be ſeen, and without which we cannot ſee any thing, is a ſubſtance diſtinct from all others, ſince it is the only one capable of rendering bodies viſible. We know alſo from the moſt deciſive experiments, that it has a progreſſive motion, whoſe direction is in a ſtraight line, and whoſe velocity is enormous, of about eighty thouſand leagues in a ſecond. It is known to be perfectly elaſtic, ſince it is reflected from bodies at an angle equal to the angle of its incidence. It is known to be inflected when it paſſes very near bodies, that it is refracted when it paſſes from one medium into another of a different denſity, which proceeds from its being ſubject like other matter to the law of attraction. *Newton* has ſhewn that light is not a ſimple ſubſtance, but that it is compounded of ſeveral ſubſtances, all which have the fluidity, velocity, elaſticity, and refrangibility of light, but which do not poſſeſs theſe qualities, at leaſt, the refrangibility in the ſame degree. Whence it happens, that when it is made to reflect, inflect, and refract, it is decompoſed, and ſeparated into its conſtituent parts, which then appear to be ſo many diſtinct and differently coloured rays. Laſtly, chemiſts have proved by many experiments, (as is ſhewn at the article *Phlogiſton*,) that this ſubſtance does actually enter as a conſtituent part into the compoſition of a very great number of mixts, from moſt of which it may be again ſeparated, and combined with other mixts. But, a being whoſe motion we know, whoſe velocity we calculate, whoſe direction can be changed, which can be collected or diſperſed, whoſe conſtituent parts can be ſeparated or united, which enters into compounds, and from which it may be ſeparated, is very certainly a real ſubſtance, and which ought to be diſtinguiſhed from all other ſubſtances, by its peculiar qualities, which no other kind of matter poſſeſſes.

In theſe reſpects, *heat* is very different from light. We cannot ſo eaſily decide, whether it be alſo a peculiar kind of matter, having the excluſive property of exciting the ſenſation of *hot*, as light has of rendering objects viſible, or if it be only a modification, a mode of exiſtence, of which all material ſubſtances are ſuſceptible without diſtinction, when they are affected in a certain manner.

The

he principal phenomena of heat consist, first, in this, that the
es which are more or less penetrated by it, excite in us, when
ouch them mediately, or immediately, sensations which we
eat, burning, which are agreeable or painful, according to
strength and the real state of our bodies.

condly, the bulk of all bodies augments in proportion as they
enetrated with more heat; but some bodies are more affected
is manner than others, according to their nature.

irdly, heat does not act as light does, in respect to the pene-
on or transmission through bodies. There are many bodies
gh which light cannot pass, namely, those which are opake.
e is also a great part of the light which falls on the most trans-
nt substances, that is reflected, or suffers, in its passage through
es, so many resistances and deviations, that it loses its motion at
h, and ceases to affect us as light does. But heat penetrates
odies, opake or transparent, and is not reflected. It is true that
astic and heated matter falling upon a body is reflected, and if
matter happens to be invisible like air, it might be thought
the heat itself was reflected, but this is an error, as I am in-
d to believe, from the following consideration.

urthly, heat is distributed and divided equally among all
es equally exposed to it, however different these bodies may be
her respects, solid, or fluid; hard or soft, dense or rare, opake
ansparent, inflammable or uninflammable, &c. When ex-
d to the same degree of heat and in the same place, these
rent bodies become equally heated, as the thermometer shews;
ough some arrive sooner than others at this equilibrium of heat,
veral authors, especially Dr. *Franklin*, have observed, but this
rence is not very considerable. But I say that this equilibrium
d not take place, if heat could only, like light, pass through
in bodies, and were reflected from all others, for the same
ons that bodies of different textures, exposed to the same light,
not, and cannot be equally luminous.

ifthly, the progress of heat is not quite equal in different
iums. It moves with less velocity through dense than rare
iums, and is always infinitely less rapid than light. It is not
eptible of decomposition, inflexion or deviation. It's progress
erfectly uniform, and not to be diverted.

xthly, heat diminishes the specific gravity of all bodies, because
ncreases their bulk. But I believe that no change is thereby
luced in the absolute weight of bodies. I know that it is pre-
ed by some, that bodies acquire some small degree of weight
eing heated, but the experiments alledged in support of this
osition do not prove it; first, because several others affirm that
r experiments were not attended with the same result, and
ndly, because these experiments cannot be truly made, as all
the

the bodies which we know of are capable of receiving changes and alteration, loſs of ſubſtance and accretion of foreign matter, by being expoſed to ſtrong heat; all which circumſtances falſify the reſults.

Seventhly, as it is certain that all bodies, when they cool, recover the ſame temperature which they had before they were heated, and that they do not acquire a greater diſpoſition to be heated again, it follows that they do not retain any of the heat acquired; that heat, in a word, is capabe of ſeparating from bodies as well as of penetrating them, without incorporating with them in any manner, whereas light is capable of combining with bodies.

It appears to me that we muſt conclude from theſe facts, that heat is ſomething entirely different from light, and that it is not even a material ſubſtance, as light is, diſtinguiſhed by peculiar properties. In fact, if heat were a matter, ſince all matter is eſſentially impenetrable, it would be impoſſible to conceive that the parts of this heat, however ſmall they may be, ſhould not meet with ſome obſtacle, ſhould not ſuffer ſome reflection, ſome deviation from the elementary particles of bodies; that they ſhould penetrate theſe particles, or ultimate atoms, which muſt be without pores, and perfectly denſe. And this ſole conſideration appears to me to prove that heat is not a ſubſtance, but is merely a particular ſtate, or mode of exiſtence, of which all material ſubſtance is ſuſceptible, without any change of the nature of ſuch ſubſtance. If we may be indulged in forming conjectures in this obſcure ſubject, I ſhould propoſe the following ideas, to which however I fix no claim, not even that of novelty *, and which I am ready to relinquiſh to adopt any other that may appear more ſatisfactory and conſiſtent with the phenomena of fire.

If it be true that all the parts of matter tend to each other, by means of univerſal attraction, or any other force, we cannot doubt that the elementary and aggregant parts of bodies are ſo placed in relation to each other, that this tendency ſhall be ſatisfied as much as their configuration, their maſſes, and the action of ſurrounding bodies will permit.

On the other ſide, it is univerſally admitted that the moſt denſe aggregates contain many pores or vacuities, and even more of theſe than of ſolid particles; and it therefore follows that the elementary and aggregant parts of all bodies, even the moſt denſe and hard, have room enough to move, and that in fact they cannot fail to move, whenever they receive ſome impulſe or ſhock, whoſe force is ſuperior to that of the attraction by which they are held in their preſent poſition.

But,

* *Bacon* had the ſame idea. It is alſo the opinion of ſeveral modern philoſophers. But I do not know that any have explained it ſufficiently.

ut, if this be the case, it is evident that no solid body can suffer ions or percussions, without a proportionable derangement of arts. But as these parts are subject to another force which tends eep them in their proper situation, they must return or ap- ch to it as nearly as they can, after the motion impressed by percussion ceases or diminishes, and this alternative being kept y the continuation of frictions or of percussions, an intestine ement of oscillations and vibrations in all the minute parts of body rubbed or struck necessarily follows, and this movement much the stronger, as these oscillations are the more rapid. it seems that this intestine motion is sufficient to produce in bodies the state which we call heat, and to give a satisfactory on for all the effects of which this heat is the cause, as we see from the following remarks.

. If heat actually consists in this intestine motion of the parts odies, every body which suffers frictions and percussions ought e proportionably heated. Accordingly this is confirmed by ex- ence, since it is certain that all bodies become so much hotter hey are rubbed or struck with more force and celerity.

. Heat dilates bodies more or less also, according to their na- , and in proportion to its intensity. This effect ought necessa- to take place, if heat consists in the shaking and vibration of parts of bodies. For these parts cannot move without a respec- change of place, and consequently without ceasing to be as iguous to each other, as they were before they had acquired motion.

. The absolute weight of bodies is not augmented by heat, ever great, and it cannot indeed be augmented, since it is pro- ed only by the motion of the parts of the heated body, without introduction of any new matter into this body.

. Heat is not reflected, for it is not possible that any thing but aterial substance, as light is, can be reflected; for heat being y a mode of existence of a material substance, it cannot be there- reflected, although heated bodies may.

. The heat of bodies is communicated to surrounding and con- ous bodies, is divided equally among them, and is reduced to a d of equilibrium. But this effect ought necessarily to take place, if t be nothing else than the motion of the parts of bodies. In this tance we only observe the general law of the communication of tion, which is always distributed with equality and equilibrium ong all the bodies which move and strike each other.

. It is impossible that heat should be fixed in any body, and erience shews that in fact it never is fixed. The same explica- n is here applicable. Nothing can be united to substances but er substances. But by the supposition, heat is not a substance, articular matter, which possesses in a peculiar manner a hot qua- lity.

lity. It therefore cannot be fixed in any body; and accordingly bodies are only hot when exposed to causes productive of heat, such as frictions and collisions, which put in motion their elementary and aggregant parts; and their heat diminishes and ceases always in proportion as these causes diminish and cease to act.

7. The light which falls upon bodies heats them so much more as it is more intense, and this is a necessary effect of its nature and violent motion. Light is a material substance, its parts are indeed so small that they can pass through the pores of all transparent bodies. But the dense particles of those bodies are not pervious to light, which can only strike upon these particles and be reflected. And when we consider the prodigious velocity of the parts of light, we must perceive that they must strike the bodies on which they fall with great violence, notwithstanding they are so minute, and that when concentrated, as in the focus of a burning glass, they may agitate instantly the parts of bodies to which they are applied, to such a degree as to produce the most violent heat that is known.

8. All bodies heated to a certain degree by collisions, even by those which are different from those of light, become nevertheless ardent and luminous in proportion to their heat. This is certainly a very remarkable effect. To explain it we must observe, that light itself is not visible, or sensible but when it is darted from bodies directly to our eyes; otherwise it makes no impression on us; so that we do not so much as suspect its presence. For this reason it is, that we do not see light during night, although excepting the small cones of the shades of the earth and other planets, the whole extent of the sphere of the sun is as much filled with the light of this luminary during night as day. This proceeds from the light not being directed towards our eyes, and therefore no other part of it is visible but that which falling upon bodies capable of reflecting it, such as the moon and other planets is darted towards our eyes by this reflection. For the same reason, we do not see the focus of a burning glass it then does not fall upon a body, although there is incomparably more light in this focus than in the surrounding space. For when we place in this focus a body capable of reflecting the light to our eyes, it then becomes very sensible, and dazzling to our sight. This being the case, it is evident that if a body passes from a state which does not permit it to dart towards our eyes the surrounding light, to another state which renders it capable of producing that effect, this body from being not luminous at first, will appear, and really become so much more luminous as its new state renders it more fit to dart to our eyes a greater quantity of light, and with more rapidity. But this is precisely what happens to cold bodies when they contract much heat by friction or percussion. Before they were heated, their elementary and aggregant parts were at rest, or at least had but

little

motion; but as ſoon as they enter into violent vibrations, as they npervious to light, they neceſſarily ſtrike with violence the of light which are contiguous to them, and dart them on all Hence theſe bodies become ſhining like ſo many ſmall according to the intenſity of their heat.

om the two laſt articles, (No. 7 and 8) we ſee how heat and mutually excite, or rather render each other ſenſible, although eſe the latter be a particular material ſubſtance, while the r is a modification which may belong to any matter. If we ve in certain bodies, and in certain circumſtances a very ſen- degree of heat, while theſe bodies do not appear to us more ous than other bodies that are leſs heated, the reaſon is, that cannot make a ſenſible impreſſion on our eyes, unleſs it be di- l and darted towards them with more force and velocity than e communicated by the colliſion of the particles of bodies, have but little motion. The velocity of light ought certainly proportionable to the ſenſibility and irritability of our organs. annot doubt but there are degrees of light which we do not ive, but which might be perceived by animals whoſe eyes were than ours. It is even very probable, that if many men were k in the dark at bodies ſo heated, as not to appear luminous ſt of them, ſome of them might nevertheleſs be able to diſ- iſh theſe bodies. This experiment has not I believe been but it certainly deſerves to be. The ſame may be ſaid of n bodies which give more light than others without being heated. It is probably owing to our thermometers not being ently ſenſible, that we cannot diſcover the greater heat of bodies which are ſlightly luminous (for it is theſe only that this caſe) over thoſe which are not luminous.

ight further add here many other conſiderations on the pro- on of the effects of light with thoſe of heat, which ſeveral ular circumſtances might make appear unequal, although it vertheleſs always the ſame. It is very poſſible, for inſtance, of two bodies of equal bulk and equal heat, heated to the ſame e, and which conſequently dart the ſame quantity of light, and the ſame velocity, one may appear much more luminous than ther. For this difference may be produced by one body g parallel or convergent rays, while the rays of the other body ge. But theſe explanations of the phenomena of heat and of , and many others which naturally occur, would lead me too I ſhall only add here a reflexion which is a conſequence of heory which I have explained on the nature of light, which at if it conſiſts only in the vibrations of the elementary parts dies, by whatever means they are put in motion, it follows he parts of no body are ever in a ſtate of perfect reſt; or at perfect reſt would be accompanied with abſolute

 cold,

cold, which probably does not exist in nature, on account of the motion of light, and the constant action of bodies upon each other.

We see from what has been said on the nature and effects of light and heat, that what we call *disengaged* or *active fire*, is nothingelse than the result of the motion of light, and also of the motion of the particles of all bodies, occasioned either by the impulse of light, or by some other impulse, and that this motion is communicated to the light which it darts in all directions. Thus two causes may produce the effects of active fire, namely, first, the impulse of light, and especially when this is possessed of its greatest velocity and intensity, as it is in the focus of a burning lens or mirror: Secondly, the frictions, percussions and collisions of bodies. The phenomena of active fire are always so much the more sensible as these two causes act more strongly: They diminish when they act with less force, and they cease when the causes cease to act. This happens, in general, to all bodies into the composition of which the matter of fire, or rather that of light does not enter, at least in a sensible quantity, as one of their principles. But there is in nature, and especially on the surface of the globe, a great many mixtures which exhibit all the phenomena of active fire, in a more permanent and more durable manner than all others, and which therefore deserve to be particularly considered. These are bodies called *combustible* or *inflammable*. What distinguishes these bodies, is that when they are once put into an igneous motion, that is, when they are made red hot, either by the collision of bodies, or by the impulse of pure light, or by the contact of any body which is in this igneous motion, they produce all the phenomena of active fire, they become burning and luminous, and preserve these qualities in the same degree, or in an encreasing degree, without the necessity of the continued action of the causes which excite active fire, as in the case of incombustible bodies, and they remain in this ignited state, till all the light which entered into their composition be disengaged: after which, the part of those bodies that remains, becomes of the class of those that are incombustible, and cannot resume or preserve its state of ignition, like combustible bodies, without the continued action of the causes which excite the active fire, as is explained more fully at the articles COMBUSTION and PHLOGISTON.

As combustible bodies produce, of some sort of their own accord, and while they are ignited, all the effects of active fire, and as there is plenty of these combustible bodies, we make use of their combustion more conveniently than we could frictions or the motion of pure light, in order to apply the action of fire to any substances, in the operations of the arts and chemistry. Thus the combustion of these bodies may be considered in this respect, as a

third

cauſe which excites the activity of fire, or rather as fire itſelf, ed of all its liberty and activity.

er theſe different explanations of the nature and effects of fire, we may eaſily form an idea of the manner in which it on different bodies, and of the changes which it makes them go. Experience proves that it cauſes decompoſition only by unicating heat. Thus, although light be the ſole ſubſtance can be conſidered as the matter of fire, it is not as light, or property of rendering bodies viſible, that it produces the of fire, but by the impulſe, or violent motion which it unicates to the conſtituent parts of bodies, which motion, as already ſaid, conſtitutes eſſentially and ſolely the ſtate which heat. This being well underſtood, no doubt can remain he manner in which I conceive the effects of active fire, and he alterations which it produces in the bodies expoſed to on.

peak properly, all theſe effects are reduced to a ſingle one, or y its conſequences. This principal effect is the dilatation bodies; and this dilatation can be only attributed to heat, reaſons I have given. But it is evident that no body can ated, without a proportionable diminution of its ſpecific , of its hardneſs, or adheſion of its parts; and theſe two es are the moſt eſſential to be conſidered relatively to che- ; for every operation of this art is effected either by the ition of ſpecific gravity, or by a greater or leſs diſjunction parts of bodies, as we ſhall ſhew.

e ſubſtances are capable of a greater dilatation or diminution r ſpecific gravity, than others, by fire. Thus certain mat- e ſo much rarefied by even moderate heat, that they ſeem to their ſpecific gravity, or become at leaſt ſpecifically lighter ll the ſurrounding bodies: hence theſe ſubſtances, when to a certain degree, are raiſed as bodies would be without . All ſubſtances which have this property are called in l *volatile ſubſtances*. Other bodies are ſo little dilatable by elatively to their denſity, that the greateſt heat that can be to them, produces an almoſt inſenſible diminution of ſpecific . Theſe are called, from their being almoſt unalterable in ſpect by fire, *fixed bodies*. Hence, if we expoſe to fire a ound body containing ſome fixed and ſome volatile principles, ter becoming ſpecifically lighter, ought to riſe in vapours, ſeparate themſelves from the former, which are unalterable reſpect. But as almoſt all compounds contain principles ng ſo much in volatility and fixity, that ſome of them may ſed and ſublimed, while others ſhall remain fixed with ſome degree of heat; we may therefore, by heat alone, make many ſes and decompoſitions. If, for example, we expoſe a com-

pound of regulus of antimony, which is a volatile ſemi-metal, and of gold, which is a fixed metal, to heat ſo ſtrong that the volatility of the regulus of antimony ſhall take place; then this ſemi-metal, being raiſed by its acquired levity, will be ſublimed in vapors, and will be ſeparated from the gold, which will remain fixed and pure. The obſervation we have juſt made concerning the changes in the ſpecific gravity of bodies, which the dilatation occaſioned by heat produces, ought alſo to be applied to the diminution of the adheſion of their integrant parts, which is an effect of the ſame cauſe; for if a body be dilated by heat, the contiguity, and conſequently the adheſion of its integrant parts muſt be diminiſhed: but in this reſpect, the ſeveral natural ſubſtances differ very much; for the integrant parts of ſome bodies, when dilated by heat, are ſo ſeparated and diſjoined, that they ſeem no longer to cohere. If theſe bodies be naturally ſolid, they become fluid when they are penetrated with a ſufficient quantity of diſengaged fire, and are called *fuſible bodies*. Thoſe bodies, the integrant parts of which cannot be entirely diſjoined by fire, are called infuſible or refractory: but as the aggregation of a body is broken when it is fuſed, and as this deſtruction of aggregation is a neceſſary condition for the combination of bodies with each other; fire, therefore, by rendering ſolid bodies liquid, has influence as a principal agent in all combinations.

As all chemical operations may be reduced to decompoſitions and combinations, fire is, therefore, in chemiſtry, as in nature, an univerſal agent. Thus we know, that although decompoſitions and analyſes may be made by menſtruums without any more than the natural heat, yet as theſe menſtruums can only act when rendered ſufficiently fluid by heat, fire therefore acts in theſe analyſes as neceſſarily as in thoſe which are occaſioned by the immediate application of heat. We ought to obſerve concerning this ſubject of the volatility, fixity, fuſibility and infuſibility of bodies, firſt, that all theſe properties are properly only relative. Not any body is entirely fixed and infuſible; and thoſe which we conſider as ſuch would be reduced into vapors, as volatile bodies are, if they were expoſed to a heat infinitely ſtronger than any we can excite. Thus a body will appear fixed, or infuſible, when compared with other very volatile and very fuſible ſubſtances: While it ſhall be conſidered as volatile or fuſible, when compared with others more fixed and leſs fuſible. In the ſecond place, as volatility and fuſibility are effects of one and the ſame cauſe, namely, of the dilatation occaſioned by the preſence of a certain quantity of uncombined fire in bodies, theſe two qualities are properly the ſame, in more or leſs eminent degrees; and in this ſenſe, volatility ought only to be conſidered as the higheſt degree of fuſibility. Accordingly, ſubſtances which are habitually liquid, and which ought therefore

to

considered as the most fusible, are all very volatile, and may
sed into vapors with very little heat; while, on the contrary,
rs that are hard, and not very dilatable; those, in short, the
gation of whose parts is the firmest and most difficultly to be
n, and which are therefore the least fusible, are also the most
The aggregation of all bodies, when reduced into vapors or
, is broken; but more so when reduced into vapors, than
merely fused. Accordingly, the most effectual of all methods
mbining substances which cannot be easily united, or which
t be joined while the aggregation of one of them is sensibly
rved, is, if possible, to reduce them into vapors, and to make
vapors meet. All the effects which fire produces, as an agent
emical operations, are reducible, as we see, to those we have
ioned. The quantity of uncombined fire which flows per-
lly from the sun, and diffuses itself through all its sphere, is
ent to produce all the separations and combinations which
ily see effected by nature: but as the heat caused by the sun
y limited, chemistry would be confined almost to the contem-
n of natural operations, if we had not methods by which pure
ncombined fire may be made to enter bodies, or to quit them
eater or less quantities.

he method of encreasing the quantity of fire or of exciting its
ty, are, 1. The impulse of concentrated light. 2. Frictions.
he combustion of inflammable bodies.

he strongest action of light that we know of is, that of the focus
urning lens or mirror. The heat which this focus excites in
s exposed to it, is even much too strong for most chemical
tions, and ought to be applied only to the most fixed and most
ctory bodies. As the focus is besides very small, and these
tions cannot be without great difficulty performed conveni-
in it, and as powerful mirrors and lenses are very rare and
very little use is made of this fire for the operations of che-
y. This Science is however indebted to it for many experi-
s of the utmost importance, as the *decomposition of gold*, pub-
l by *Homberg*, if it be true, the *fusion of platina* which I have
ed along with M. *Beaumé*, and that of several other bodies
h cannot be fused by other fires without addition, as has been
n by different Chemists.

he heat which is excited by frictions and percussions is in gene-
roportionable to the force, to the rapidity, to the extent of
riction or percussion, as well as to the hardness of the bodies
ed or struck. This heat is also little used in chemical opera-
; but appears nevertheless very frequently in many experi-
s, as in fermentations, effervescences, solutions. It takes
whenever bodies unite together, and is proportionable to the
and rapidity with which these bodies re-act upon each other.

It is produced by the friction and collision of their parts; which indicates that the primary particles of bodies are of the greatest degree of hardness, even in those bodies which are habitually liquid or soft; for these bodies, during their solution or re-action, are capable of producing as much heat as the hardest substances; and if the agitation of some fluids does not produce any sensible heat, the reason is, as M. *de Buffon* says, that their parts cannot touch or strike each other in such a manner as to produce a sufficient collision.

As to the combustion of those bodies that are combustible, it is, as I have said, the most convenient and advantageous method of applying the action of fire to bodies.

The most common inflammable substances, such as wood, pit-coal, charcoal, and oils are those which are generally used in Chemistry, as well as in the Arts and in common life, for all the operations in which the action of fire is wanted.

Chemists having occasion for all the degrees of heat from the weakest to the strongest, have sought and found the means of procuring them by employing different intermediate substances, and still better by the disposition and construction of furnaces, in which are contained the combustible matters and the substances to which the action of fire is to be applied.

It is certainly not without grounds that the *Count de Buffon* remarks in the first volume of his introduction to the history of minerals, that the action of fire upon different substances, depends greatly on the manner in which it is applied. Experience proves in fact, that certain matters which melt easily enough in the fire of a forge or of a large furnace, resist the focus of a burning lens or mirror, although this focus melts other matters which are infusible, or whose fusion requires great time, by any other mode of applying heat. To explain these facts, M. *de Buffon* thinks that we ought to consider fire in three different states, the first relative to its velocity, the second to its bulk, and the third to its mass. Under each of these points of view, according to this illustrious Author, this element so simple, so uniform, in appearance, will seem to be a different element. M. *de Buffon* explains afterwards how we may encrease the velocity, the bulk, and the mass of the fire, and make it produce different effects according as its activity is encreased by one or other of these means. I cannot but applaud the new ideas which this ingenious man proposes on this subject, and which appear to me to be generally well founded. Nevertheless, as each person has his own manner of considering things, and, as M. *de Buffon* himself expresses, the empire of opinion is sufficiently large for every one to wander in it, as he pleases, without offending each other; I will hazard a few words concerning my sentiments on the differences of the effects of fire, from the ideas which I have explained in this article, on the nature of this powerful agent.

Fire

ire does not act or produce any alteration upon bodies, but by ns of exciting heat in them, and heat is nothing but the mo- of the conſtituent and aggregant parts of heated bodies.

f theſe propoſitions be true, we can ſafely conclude that the ſure of the action of fire is the product of the maſs of heated ies by the velocity of the vibration of their particles; and this g the caſe, it is evident that as we have not any means of en- ſing the velocity of the light darted from the ſun, we cannot reaſe its heat but by encreaſing its denſity, as is uſually done in foci of catoptric and dioptric inſtruments, as M. *de Buffon* ly remarks. I believe we may add, that for the ſame reaſon, en we heat bodies by frictions or percuſſions and independantly he action of light, we cannot encreaſe their heat by any other ns, than by encreaſing the oſcillatory velocity of their parts, rubbing or ſtriking them more ſtrongly, or rapidly, ſince it is lent that by friction or percuſſion, the maſs of the bodies rubbed truck cannot be changed. We ſee then two caſes in which the on of fire may be increaſed, the former by augmenting the maſs, the latter by augmenting the velocity. But theſe two fires, ecially the latter, are of no uſe in chemical operations, for the ons above aſſigned. The fire which we are moſt inter- d in the knowledge of, is that of combuſtion. The effects of fire may be greatly encreaſed, we cannot ſay how much, by reaſing the acceſs of air, and bulk of burning matters. But as fire reſults from the diſengagement of light, and from the in- ine motion of the parts of the burning bodies, we cannot ſo ly know, whether its force be encreaſed by augmenting its maſs its velocity. Perhaps the encreaſe of velocity may take place certain degree by the communication and augmentation of the tions of a great many igneſcent and contiguous parts. But as as I can judge, this effect is only ſecondary, and occaſional in h caſes, and for the following reaſons.

I grant that a fire of combuſtible matters which becomes infi- ely hotter and more luminous by the blowing of bellows, or by other rapid draught of air, has very much the appearance of re whoſe activity is encreaſed by a new degree of velocity im- ſſed by the current of air; but this is only an appearance, or I much deceived. In fact the impulſe of air upon a burning dy, cannot encreaſe the velocity of the fire, but by encreaſing it of the parts of bodies put in motion by combuſtion, or that the light which is diſengaged in this combuſtion. But, it ap- ars to me that the ſtrongeſt impulſe of air cannot produce either theſe effects. For, firſt, it is certain from experience, that the pulſe of the air puſhed upon any body with the greateſt known olence cannot agitate the parts of this body ſo ſtrongly as to pro- ce any ſenſible heat. The moſt impetuous, natural or artificial

wind is not able to produce any alteration in the temperature of bodies. Besides the impulse of air can still less accelerate the velocity of light, not only because its greatest velocity is so exceedingly small when compared with that of light, but also because it is not capable of any sensible hold upon the parts of this substance, as is demonstrated by a well known experiment. We know in fact, that the most violent blast directed upon the focus of a burning glass does not produce any change, neither augmenting, or diminishing its activity, or altering its direction.

But if it be asked by what means then does a current of air encrease so considerably the activity of all kinds of fire which proceeds from combustion, I shall make the following answer.

All philosophers agree that air is an ingredient or agent absolutely necessary to combustion, that the most combustible bodies cannot burn without its immediate contact, and that the more compleat this contact is, the more active is the combustion. This being the case, it is evident that if we encrease the quantity of air which comes into contact with the parts of any combustible body, we shall proportionably augment the quantity of those parts which burn at one time; but as it is the quantity of ignescent particles in the same space that is thus encreased, it follows clearly, that it is then the mass of fire and not its velocity which is thus encreased.

With regard to the augmentation of the effects of fire, by encreasing its bulk, it requires other considerations. Heat being really nothing else than the motion of the parts of heated bodies, all the phenomena of heat cannot differ in any respect from the phenomena of moving bodies; and it follows from thence, that the communication of heat from one body to another must be exactly similar to the communication of motion from one body to another. But motion is communicated according to certain laws, which indeed vary as the hardness and elasticity of the striking bodies vary; but it is certain, that in general, whatever be the velocity and density of moving bodies which strike other bodies at rest, these qualities being determined and remaining the same, the bodies that are struck receive so much more motion from the striking bodies as the latter surpass the former in number and in bulk, and *vice versa*; so that if a considerable quantity of matter at rest is struck by a very small quantity of matter in motion, it will not thereby be sensibly moved, whereas its motion will be very great, if these circumstances are reversed. It follows from hence, that in order to produce a determinate motion in any given quantity of matter, by the impulse of a quantity of matter in motion, of a given velocity and density, it is necessary that the quantity or bulk of this moving matter should be proportionable to the quantity or bulk of the body to be moved, and in order to procure this determinate degree of motion, in the matter which is to be moved,

it

ought to be ſtruck by a proper quantity or bulk of the matter at is to communicate the motion. Now, in applying theſe inteſtable principles to the communication of heat, we ſhall ſee at it follows the ſame laws as thoſe of the communication of otion. In fact, if heat be nothing elſe than the motion of the rts of heated bodies, as I ſuppoſe it to be, it follows, that in der to produce a determinate heat in any body, ſuch as the heat ceſſary for the fuſion of that body, it muſt be expoſed to the tion of ſome other matter in the ſtate of igneous motion, the antity or bulk of which are proportionable to the quantity or lk of the body to be melted. This truth is proved by a very mple and common experiment. It is known that glaſs or iron ay be melted at the flame of a common canule, as well and as ickly as in the largeſt and hotteſt furnaces; and that this deends ſolely on the relation of the bulk of the matter to be melted th that of the fire which is to melt it, ſo that the bulk of the re of glaſs or of iron thus expoſed to the flame of the candle beg ſmaller relatively to the bulk of the flame, than the bulk of a ge maſs of ſeveral quintals of theſe matters, is with regard to at of the fire of the furnace, the fuſion will be more compleat and ick in the former than in the latter caſe.

Theſe facts appear to me to furniſh a new proof of the analogy tween the phenomena of the communication of heat, with thoſe the communication of motion, and the reſult is, that in whater manner the fire be applied to any body, whether its activity augmented by an encreaſe of its velocity, of its maſs, or of its lk, its effects are always exactly the ſame, on the ſame body, hen the degree of heat communicated to it is the ſame; and that white and diaphanous bodies, for inſtance, reſiſt more the fire catoptric and dioptric foci, than the fire of combuſtion, the reaon is, that theſe bodies are really leſs heated in theſe foci, which nſiſt of a pure light, that they have the property of reflecting or anſmitting, than in the fire of combuſtion, in which, beſides the rts of pure light, the parts of the igneſcent bodies which are obably denſer than thoſe of light, do conſequently ſtrike them ith more force. I have lately made ſome very ſimple experiments hich I have communicated to the academy of ſciences. They onſiſted in expoſing to the focus of a burning glaſs, ſeveral plates glaſs of different degrees of whiteneſs and thickneſs, without pport, and holding them at the end of a pair of tongs. When e thickneſs was equal, the glaſſes which were leaſt white, melted oſt eaſily and quickly; which agrees very well with the fact alady known, that coloured bodies heat quicker and ſtronger than hite bodies in the rays of the ſun. But what is moſt remarkable nd important in theſe experiments, is, that with equal degrees of hiteneſs and tranſparency, the thickeſt glaſſes melted more eaſily

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than the thinner; so that a plate of glass as thin as paper, which could be melted instantly in the flame of a candle, was not even softened in the focus, which however, melted pretty large pieces of iron, and made them dart sparks to the distance of a foot.

This experiment seems to prove, that bodies exposed to the mere action of light, receive so much less heat, as they have more of the property of reflecting, without being penetrated by the rays, as was already known; and further, that their heat is also so much less, as they give a freer passage to the rays of light; and it follows evidently from thence, that the bodies which are capable of being heated the most strongly by the action or impulse of light, are those which reflect the least, absorb the most, and transmit the smallest quantity. But how shall we conceive the production of the most violent heat in these latter bodies, unless we consider heat to consist in the agitation and oscillatory motion of the smallest parts of these bodies, occasioned by the impulse of those of light? Why should so much light be able to penetrate within the bodies, and not be able to pass through easily and freely, and leave them? Certainly we cannot imagine any other reason, than the collisions of the particles of light against those of the bodies which it heats, these collisions being so much more multiplied, as light penetrates in greater quantity into bodies, or as it meets with more obstacles to its motion in a right line, by which means it is reflected, and turned in a thousand directions within the bodies, before it can get out of them, while it loses as much of its motion as it communicates to the resisting particles of the bodies by all these collisions. Does it not follow clearly, that light can heat bodies only in proportion, as it communicates its own proper motion to their parts, and that consequently heat is nothing but the agitation and motion of the heated particles?

I have hitherto been of opinion, I confess, with most natural philosophers, that heat was a particular kind of matter, so subtle as to penetrate all bodies, and to separate their parts, when put in action by light or by percussion; and that this being was the true matter of fire; but the above reflexions have suggested a very different opinion. There certainly is a matter of fire: and it is pure light, which is a material substance, whose existence cannot be questioned. But we cannot say the same of heat; the causes which excite it, and the effects which it produces, do not prove, or even suppose the existence of a particular matter. They all concur on the contrary to indicate that it is only an accident, a modification of which some bodies are susceptible, and consisting merely in the intestine motion of their aggregate and constituent parts, and which may be produced not only by the impulse of light, but also by all frictions and percussions of any bodies.

Anti-

*Additions to the Article* GOLD *of the former Edition.*

THE fixity of gold, although very great, is not perfect, no more than it is of other bodies, which have been considered the most fixed. This fixity is only relative to the degrees of heat, to which these bodies may be exposed. Accordingly, gold is not truly fixed, and does only resist without loss the action of the fire of furnaces, for if it be exposed to a much superior heat, such as that of a large and good burning glass of three or four feet diameter, it is certain that it suffers, even in a little time, a sensible loss. I have held some very fine gold in the focus of a burning glass belonging to the academy, at several times, and during half an hour each time, sometimes in a hollow piece of charcoal, or in vessels made of earthen ware and porcelain, and whenever the air was very clear and the sun very bright, I and several other members of the academy observed, that a very sensible smoke arose from the gold to the height of three or four inches. To know what was the nature of this smoke, I exposed to it a cold silver plate, by which means some of the vapour appeared upon the silver like a tarnish a little less white, but not sensibly yellow. But when this part of the silver plate was rubbed with a burnisher, it appeared so evidently to be gilded, that none of the persons present could doubt that the smoke of the gold which was thus fixed to the silver, was a portion of the gold itself reduced into vapours by the violence of the heat of the focus.

Some chemists pretend to have *calcined gold*. *Homberg* says, in the ancient memoirs of the academy of sciences, that having exposed gold to the focus of *Tschernhausen*'s great lens, he has seen it smoke, and reduced to a green violet colour. But according to the tradition which is preserved in the academy, this experiment has not all the authenticity that is necessary, and it requires to be repeated with the greatest care.

As it was an experiment of great importance, I thought it proper to verify it, after the academy had charged me together with Messrs. *Montigny*, *Cadet*, *Lavoisier*, and *Brisson*, to make a course of experiments with the great burning glass belonging to the academy, which was the same as that which Mr. *Homberg* had employed. I exposed gold of twenty-four karats fine several times to the focus of this glass, during half an hour at a time, on dishes made of very refractory white porcelain earth.

When the gold was melted, which happened in the space of some seconds, it took a spherical form, excepting on the side where it touched the support, and where it was flattened by the weight of the mass, precisely as happens to mercury, and this sphere soon acquired a rotatory motion round its axis, sometimes in

in one direction and sometimes in another, according as it received the impression of the focus more vertically, more horizontally, or more laterally, and whether from one side or from the other.

At the same time, when the focus was at its greatest heat, a very sensible smoke arose, as Mr. *Homberg* had observed, and the nature of which I determined by the experiment above mentioned.

On the surface of the spheres of gold, I saw gradually formed, spots evidently vitrified, which separated from the gold, and reunited upon most of the spheres into one mass of a dark violet coloured glass, and of a greater curvature than that of the mass of gold, in which they were found to be set as jewels are in a ring, and producing nearly the same appearance as the transparent cornea has on the globe of the eye, that is, as the segment of a small sphere joined to the surface of a greater. I have obtained upon a semi-spherical mass of gold, whose diameter was about half an inch, which might have been exposed to the focus, about four hours in all, a button of this violet glass whose diameter was more than two lines; and this glass was observed gradually to increase, while the gold diminished. It is very probable, that the violet glass obtained by Mr. *Homberg*, was of the same nature as mine. These glasses do certainly resemble much a vitrification of gold: Yet I do not think that we can conclude with certainty the vitrescibility of this metal; because, although I have not remarked any vitrified parts upon the earthen supports that I used, it is nevertheless possible, that some parcels of these supports, or some atoms of dust floating in the air, especially as our experiments were made in a garden, might have furnished the matter of these vitrifications. I think that in order to decide upon the nature of this vitrified matter, this experiment ought to be carried as far as it can go, that is, the gold ought to be exposed to the focus, till all the gold be vitrified or evaporated, till nothing remains but this violet glass, of which there ought to be a sufficient quantity to determine whether it can be revived into gold by addition of a phlogistic matter, like the other metallic glasses; but the experiment carried to this point would be much longer and more difficult than could be believed from several reasons, of which I shall speak at the article BURNING GLASS, and principally from the few days which can be found in this climate, sufficiently favourable to such experiments. This is so much more difficult and thorny, as the gold in the focus is in several different states, and mixes more or less with the vitrified matter. For independantly of the portion of gold which evaporates without being decomposed, the bottom of the earthen vessels, or the hollow of the charcoal in which I exposed this metal to the focus, were always observed to be coloured, even at a considerable distance from the place where the gold rested, with a purple

purple matter, and ſprinkled with many ſmall globules of gold not decompoſed, ſome of which are ſenſible to the naked ſight, but which are multiplied prodigiouſly when examined by the microſcope. Many ſimilar particles of gold may be alſo ſeen in the violet glaſs. This purple ſtate of gold is not yet well known; it appears nevertheleſs to be a kind of calcination of this metal by which it is rendered capable of being vitrified. But we may eaſily perceive, that before we try the reduction of the purple glaſs which I have obtained, it will be neceſſary to expoſe it to the focus till all the little particles of gold with which it is ſprinkled, ſhould be entirely vitrified, or evaporated. I ſhall not neglect any opportunity of proſecuting and compleating this experiment; but as it is very poſſible that the time which I have to live will not be ſufficiently long for that purpoſe, I ſhall leave to the academy of ſciences the materials of theſe experiments with notes, that they may be continued and finiſhed after my death.

## *Addition to the Article* FULMINATING GOLD.

THE effects of fulminating gold have made ſeveral chemiſts, and particularly myſelf, conjecture that the fulmination was cauſed by the detonation of a part of the nitrous ammoniac ſalt that is combined and adheres to the fulminating gold in its precipitation. This explanation appears in fact ſo much the more natural, as in all the proceſſes known till very lately, for the preparation of fulminating gold, a nitrous ammoniac ſalt will be formed; as this ſalt has the property of detonating without addition, and as the augmentation of the weight of the precipitate, ſeems to indicate, that a portion of it combines very intimately with gold in its precipitation. But Mr. *Bergman* has overturned this hypotheſis in an excellent memoir which he publiſhed ſome years ago upon this matter.

The intereſting and numerous experiments which this illuſtrious chemiſts relates in his memoir, prove clearly that the nitrous ammoniacal ſalt, and the nitrous ſulphur, have no part in the fulmination of gold. The moſt deciſive is, that Mr. *Bergman*, after having diſſolved without nitrous acid, a precipitate of gold that did not fulminate, gave it a ſtrong fulminating property by precipitating it again with volatile alkali. From Mr. *Bergman's* experiments it appears, that neither vitriolic acid, nor fixed alkali, nor waſhing with a large quantity of diſtilled water, even when boiling, are capable of depriving fulminating gold of its fulminating property; and that inflammable bodies, ſuch as ether, are more capable of producing this effect. But the moſt aſtoniſhing and remarkable circumſtance is, that Mr. *Bergman* was able to deſtroy the properties of fulminating gold, by interpoſing between its parts

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any body, by a trituration (which ought to be carefully managed) and by a calcination, with the ſtrongeſt degree of heat that it could bear without fulminating, which required no leſs dexterity and attention. Theſe facts, added to the light which Mr. *Beaumé* ſays he has perceived upon fulminating gold when ready to explode, prove that it is owing to the ſudden and inſtantaneous inflammation of ſome very combuſtible matter. But what this combuſtible matter is, has not been yet determined. Mr. *Bergman* has only proved that it proceeds from the volatile alkali which tranſmits it to the precipitate of gold; and from a great many experiments which he has made on this matter, it appears that he was not able to make fulminating gold without volatile alkali, and that on the contrary, he has obtained ſome that was ſtrongly poſſeſſed of the fulminating property, by applying this ſaline matter to this metal when much divided. It appears then to be certain, that gold does not become fulminating, but by the means of volatile alkali. But how does it happen that volatile alkali and gold, which ſeparately do not produce any detonation, and are not even ſuſceptible of an evident inflammation, form with one another a compound capable of the moſt ſudden and violent inflammation that is known? This remains to be determined. As at preſent we can only make uncertain conjectures concerning the cauſe of this phenomenon, I ſhall not attempt to explain it. I ſhall obſerve only to thoſe who would examine this matter, that the properties of volatile alkali, and eſpecially thoſe by which it differs from fixed alkalies, have long ago demonſtrated to chemiſts, that a ſenſible quantity of the principle of inflammability enters into the compoſition of this ſaline ſubſtance, and that Dr. *Prieſtley* has lately found in his experiments upon gaſes, that volatile alkali is one of the ſaline matters which is capable of aſſuming the aerial aggregation, that is, of a permanently elaſtic fluid, and that in this ſtate it is poſſeſſed of a ſtrong degree of inflammability.*

*Addition to the Article* GRAVITY *of the former Edition.*

ALTHOUGH general and particular *gravity*, which is nothing elſe than *attraction*, be demonſtrated by a number of facts, it is of ſo great importance to the theory of chemiſtry, that we cannot ſupport it on too many proofs: and therefore I ought to mention here one of the fineſt experiments which have been lately made in natural philoſophy, and which ſeems to me to demonſtrate this great principle in the moſt ſenſible manner. Mr. *Moreau* is the author of it. He judged, with reaſon, that it was eſſential to demonſtrate the exiſtence of a *particular attraction* even to perſ[illegible] a little converſant in chemiſtry, by an experiment made on bodies ſo large, as to render it infinitely more ſtriking and more ſenſible than it

* See the Treatiſe on Gaſes, Chap. X and XV.

is in the chemical operations, in which it is exerted only by lecules so very small as to be quite out of the reach of our senses. exhibited this capital experiment before the academy of sciences *Dijon*, (of which he is an illustrious member) in February, 73, and he published it in the first volume of *Rozier's Journal*, d also in the first volume of his *Elements of Chemistry*. If this re the only experiment on the subject, it would sufficiently ve the chemical attraction, which Mr. *Morveau* makes the basis his theory. It is thus related. "If a balance be put in equilio, at one arm of which is suspended a round plate of glass, ose diameter was two inches and a half, by means of a hook ened to the upper surface of the arm of the balance; and if s piece of glass be made to descend upon the surface of the mery, placed below at a small distance, it will be necessary to add he scale at the opposite arm of the beam, a weight equal to e gros, and eighteen grains, in order to disengage the glass m the mercury, and to overcome the adhesion resulting from contact. The experiment succeeds equally well in an exusted receiver, and therefore is not affected by the compression the atmosphere, but is merely the consequence of *attraction*." is proof is evident not only to chemists and to natural philosoers, but also to others.

This fine experiment is rendered still more decisive, and more ative to chemistry, by the methods in which Mr. *Morveau* has ied it. Instead of the glass plate, he substituted plates of difent metals and semi-metals, of an inch in diameter. And as se metallic substances have different degrees of affinity with rcury, they accordingly shewed different degrees of adhesion, ich are shewn by the following number of grains which were uisite to separate each of these substances from this metallic id.

| | | | |
|---|---|---|---|
| *Gold* | required | 446 | *grains.* |
| *Silver* | —— | 429 | —— |
| *Tin* | —— | 418 | —— |
| *Lead* | —— | 397 | —— |
| *Bismuth* | —— | 372 | —— |
| *Zinc* | —— | 204 | —— |
| *Copper* | —— | 142 | —— |
| *Regulus of Antimony* | | 126 | —— |
| *Iron* | —— | 115 | —— |
| *Cobalt* | —— | 8 | —— |

The most remarkable circumstance in these experiments, (the ults only of which I mention, and I refer to Mr. *Morveau's* pubations for the details) is that the order of the adhesion which s observed between the different metals and mercury, is precely that of the affinities of these matters to each other, as they appear

appear in amalgams, precipitations, and other chemical operations, and marks the degrees of the greater or less solubility of metals by mercury, as they have been ascertained by known observations. See the *Tables of Affinities* at the article *Affinity*. "Nobody can (Mr. *Morveau* judiciously adds) be tempted to consider, as a matter of chance, an analogy so constant, and a correspondence between so many effects. It is then demonstrated, that the cause of adhesion is the same as that of solution, and that as attraction is the principle of the former, it is also the principle of the latter."

Mr. *Morveau* proceeds farther, and he even hopes to be able to subject chemical affinities to calculation, and to estimate them with mathematical accuracy. "Here we have (says he) affinities determined by numerical relations. Thus we may say, that the affinity of mercury with gold is to the affinity of mercury with zinc, as 140 is to 204; and it is evident what accuracy would be introduced into chemistry by these mathematical expressions. We have reason to hope, that when we shall have, by experiments purposely made, collected a sufficient number of these terms, geometry rectifying her calculations, at first upon false suppositions, and afterwards rectifying her results by comparing the same effects in different circumstances, will one day come to demonstrate rigorously the figures which the elements of certain bodies ought necessarily to have, in order to produce a certain determinate sum of points of contact; and to exhibit, after they are re-united, these masses that are regularly subjected to certain forms."

This is certainly one of the finest prospects which we can have in chemistry. And although it does not appear to be without foundation, it belongs solely to geometricians to determine what may be considered as possible in this matter.

I cannot better terminate this article, than by adding the specific gravities of metals, determined by Mr. *Brisson* with more accuracy than has been done before. I shall only repeat the principal results of the experiments made in order to determine the specific gravities, and I refer to Mr. *Brisson*'s memoir for the detail. The specific gravity of each metal has been compared by Mr. *Brisson* with that of rain or distilled water, of which the French cubic foot weighs 70 French pounds; and the air being at the temperature of the 14th degree above zero, according to Mr. *Reaumur*'s thermometer, the weight of any bulk of water being supposed to be 1000, an equal bulk of each metal, not being hardened by beating, and when very pure, was found to be according to the expressions in the following table:

Specific

| | Specific Gravity. | Weight of one cubic inch. | | | Weight of a cubic foot. | | | |
|---|---|---|---|---|---|---|---|---|
| | | oz. | gros. | grains. | pounds. | oz. | gros | grains. |
| ter | 1000 | | | | | | | |
| ld | 19257.2 | 12 | 3 | 62 | 1348 | 1 | 0 | 41 |
| er | 10474.3 | 6 | 6 | 22 | 733 | 3 | 1 | 52 |
| pper | 7788 | 5 | 0 | 28 | 545 | 2 | 4 | 35 |
| s | 8395.8 | 5 | 3 | 38 | 587 | 11 | 2 | 26 |
| ged iron ry soft | 7788 | 5 | 0 | 28 | 545 | 2 | 4 | 35 |
| English Steel | 7833.1 | 5 | 0 | 44 | 548 | 5 | 0 | 41 |
| d | 11352.3 | 7 | 2 | 62 | 794 | 10 | 4 | 44 |
| ofCorn-, pure. | 7291.4 | 4 | 5 | 58 | 510 | 6 | 2 | 58 |

N. B. The specific gravity of metals hardened by being beat found to be a little more, according to Mr. *Brisson*'s memoir. Mem. de l'Acad. des Sciences, 1772. Partie. II.

*Addition to the Article* IRON, *of the former Edition.*

*TAHL* has advanced that *marine acid* treated with iron can acquire the properties of *nitrous acid*; but without foundation. Mr. *Macby*, and more especially the *Duke d'Ayen* have exned this fact. This research gave occasion to the *Duke d'Ayen* ake the numerous series of fine experiments, which are red in four memoirs communicated to the academy of sciences, *he effects of the combinations of acids with metallic matters.* To e memoirs I am sorry that I am obliged to refer for many inlling particulars. I shall only in general take this opportunity nouncing them to chemists, and of saying, that the title shews great extent of this subject, and that notwithstanding the unmon zeal of this nobleman, he has not yet been able to comt in all its extent the task he has imposed on himself. The four noirs above-mentioned are upon the subject of the combinas of nitrous acid, marine acid, aqua regia, and acid of vinegar copper, iron, tin, lead, and zinc. Although several of the ts of these acids with these metallic matters, were already wn, many new ones could not fail to occur in the exact, but nnunately too little practised, method which the *Duke d'Ayen* loyed in his research. The acids and metals used were ectly pure; the combinations were made with much larger nities of matter than are usually employed in experiments. weights of the materials, the degree of concentration of the s, the phenomena of their action upon each metal, the quanof the metal dissolved by each acid, have been all carefully ascered. Lastly, the different degrees of adhesion of the acids to

the metals have been determined by the beſt method which chemiſtry affords; namely, the decompoſition of the metallic ſalts by a graduated heat. By diſtilling each of the combinations in retorts, firſt with a ſand bath, and afterwards in the naked fire, the *Duke d'Ayen* judged of the quantity of each acid that remained united with each of the metals at equal degrees of heat, from the degree of concentration of the acid that paſſed into the receiver, and from the weight of the reſiduum; and theſe intereſting experiments have proved ſtill more completely than had been done before, that marine acid adheres much more powerfully to metals than nitrous acid does, and that it alters them much leſs in their compoſition.

But independently of theſe general reſults, the ſame experiments have preſented to the *Duke d'Ayen* many particular phenomena, which are very curious, and ſeem to be capable of leading to important diſcoveries. For example, to return to the combination of marine acid with iron, mentioned in this article; the decompoſition of the marine martial ſalt, which reſults from the union of theſe two ſubſtances, yielded by diſtillation and by calcination, the moſt ſingular products, which this experiment alone could have diſcovered. With a moderate heat, nothing paſſed into the receiver but a kind of phlegm ſlightly acid; which ſhews that this acid adheres ſo ſtrongly to the iron, that it can reſiſt the action of the fire that is neceſſary to deprive it of all its phlegm, and may be be concentrated to dryneſs in this marine martial ſalt; in which reſpect it differs much from nitrous acid. But when the *Duke d'Ayen* applied to this combination a much ſtronger heat, very different effects followed. A part of the concentrated marine acid was carried off, and, (as this acid uſually does) raiſed along with it a portion of the iron, under the form of a red, ochery, very ſtiptic and very deliqueſcent ſalt, among which there were alſo ſome red cryſtals that were not deliqueſcent. What is very remarkable, is, that, at the ſame time, there was ſublimed to the arch of the retort, a cryſtalline matter, extremely light, conſiſting of laminæ formed like razors, perfectly white and tranſparent, and decompoſing light like the beſt priſms, ſo that, according to the direction in which they were viewed, they exhibited the various colours of the rainbow.

The ſubſtance which remained at the bottom of the retort after the matter had been ſublimed, was a ſtyptic and deliqueſcent marine martial ſalt, ſingularly brilliant, in its colour, and in its form foliated, ſo that it reſembled Muſcovy-talk ſo perfectly, that it could not be diſtinguiſhed from it but by the touch.

Laſtly, this martial talky ſalt expoſed to a ſtill greater heat in an earthen retort, yielded another ſublimate no leſs ſingular than that above-mentioned, but of a very different kind. It appeared

form of a metallic matter, consisting of small and brilliant par-, which lined the upper part of the vessels. The minuteness ese metallic molecules is such that it could not be discerned e naked sight, nor even by a magnifying lens, whether their was regular. But a good microscope discovered them to be regular bodies, very opake, of the form of flat slices cut off gonal prisms, that is to say, like the earthen-ware tiles used ving floors. These ferruginous crystals, whose facets have lour and brilliancy of the best polished steel, do not seem to a saline state, but appear to be iron itself sublimed by the of fire and by means of the last portions of marine acid. It ain, that they were attractable by magnets.

e may judge from this abridgement of what is said in the *Duke* 's memoir, concerning the combination of iron with marine how many new and curious discoveries may be made, by simi- searches, on the subjects supposed to be the best understood emistry. I shall have occasion to quote several other disco-, no less interesting, which have been the fruit of the *Duke* 's first researches in chemistry.

e means which he employed was not those of a person who t only for a frivilous amusement in taking a superficial view ubject, without searching to the bottom those points which d not very brilliant; they were still less those of certain nders to chemistry, whose sight seems to be so dazzled by the marvellous, or blinded by avarice, that they are not sensible importance of any truth, but those which flatter their chime- expectations: but they were the means of true philosophers, eding in a regular and connected progression from experiment periment, not in order to force nature to pronounce oracles rmable to our pre-conceived ideas, but to receive the accurate ers which she never fails to give to those who in a proper man- terrogate her.

e marine martial salt, made by distilling iron with spirit of is soluble in spirit of wine. Although it be very deliquescent, y nevertheless be crystallised, when it is considerably reduced vaporation, and afterwards left to cool. The form of its crys- is in very small needles heaped confusedly one upon another. y be melted, as Mr. *Monnet* remarks, with a very gentle heat. *getable acids* are also capable of acting upon iron. We learn the memoirs of the *Duke d'Ayen*, quoted above, that radical gar dissolves filings of iron by means of heat, but with less than the mineral acids do; that this acid adheres very weakly on, since it may be easily separated from it by distillation; that his operation, no part of the iron is sublimed by the acid of gar; and that the remaining iron is so little altered by having thus dissolved, that it retains its magnetic property.

Mr. *Monnet*, who made the same combination, without having known the memoirs of the *Duke d'Ayen*, which are not yet printed, says, in his treatise on the solution of metals, that the solution of iron in radical vinegar, when saturated, is red as blood, that it passes with difficulty through the filter, and lets a quantity of ochre deposite; that it has not nearly the same stipticity which the combinations of iron with mineral acids have; that, by evaporation, some ochre was precipitated; and that by the subsequent cooling, small, oblong, brown crystals were formed; that this salt when put upon burning coals, easily parts with its acid, and is reduced into a martial calx of the colour of Spanish snuff, which is again soluble in acids and capable of being attracted by magnets. These facts agree very well with those observed by the *Duke d'Ayen*.

*Tartar* acts also upon iron, and even very sensibly. But the combination of these two substances is not yet well known, because tartar is a very compound substance, whose proximate principles suffer alterations and separations, during its action upon other matters. Combinations of tartar with iron have been made long ago for the use of medicine, such as the *tartarised tincture of iron*, *martial extract*, *martial soluble tartar*, *martial balls*; but from want of a distinct knowledge of the different constituent parts of tartar, what happens in these combinations was not well understood.

Since Messrs. *Duhamel*, *Margraaf*, and *Rouelle* have discovered that a fixed alkli ready formed and united with the other principles of this saline compound, other ideas have arisen concerning the combinations of tartar. Mr. *Monnet* thinks from some experiments which he has made, that the acid of tartar is the marine acid disguised by the oily and earthy matters to which it is united in the tartar. This may be the case; but if it be so, it remains to be explained how this disguised marine acid is affected in the different combinations of tartar, both relatively to the portion of fixed alkali which makes part of the tartar itself, and to the other substances on which the tartar acts? And this is what I believe is far from having been cleared up. Mr. *Monnet* does indeed pretend to explain, his treatise on the solution of metals from page 77 to 90, all the complicated effects which occur in these combinations. But I confess that after having many times read over and over, with all the attention I could give, the explanations of this able chemist on this subject, I could not clearly understand his meaning. I leave to Mr. *Monnet*'s readers to determine whether the fault lies in my want of penetration, or in his expressions not being sufficiently clear. At the article *tartar*, I shall relate what is at present known concerning this saline substance, which is certainly much compounded, and which, Mr. *Monnet* says, has been an inexplicable enigma; till he undertook to explain it.

Mr.

*Monnet* has alſo made ſome experiments on the combination tive ſalt with iron; and the reſult is, that theſe two matters nite and form a ſalt in very ſmall yellowiſh, ſilky, opake s, which cannot be diſſolved in leſs than four times the quan- water that is neceſſary for the ſolution of pure ſedative ſalt,

*Addition to the Article* MILK *of the former Edition.*

ILK. It is proper to obſerve, that as milk, and conſequently whey, do not contain any principle more volatile than water, g of theſe compounds is loſt by expoſing them to any degree not greater than that of boiling water. Thus by evaporating n a water-bath, all its parts are obtained confounded with ther, and ſeparated from the water in which they had been, f them diſſolved, and others only mixed. M. *Bucquet* has ed, that milk expoſed to the heat of diſtillation, ſuffers a co- on ſimilar to that which happens to animal lymph, and that oagulation cannot be attributed to the loſs which the milk s of its watery part; for the reſiduum cannot be again diſ- in water, even with a boiling heat.

*man*, who has made intereſting reſearches upon cow's milk, mpariſons with that of ſeveral other animals, has imagined, y re-diſſolving all that is ſoluble in water, of the ex- f milk, he could obtain a liquor analogous to whey; and in the water ought to take up from this extract, ſome of the o-ſacharine matter, the ſalt of milk, and the other ſaline ſub- which milk contains, without diſſolving any or but very lit- the butyraceous and caſeous parts, which are not naturally e in water, and whoſe connexion with the other parts of the ought to be diminiſhed by the effect of the heat of a long eva- on. The butyraceous part ſwims on the ſurface of the water, e caſeous remains undiſſolved in it, as the coagulated animal does. When this liquor, which may be thus charged at re with the principles of whey, is filtrated, it becomes the ration called *Hoffman's whey*; it is much leſs uſed than ordi- whey, becauſe the latter is more expeditiouſly and eaſily pre- . The late Mr. *Geoffroy* has given an analyſis of whey when ed in a retort. His proceſs conſiſted in evaporating to dryneſs liquor in a water-bath. He afterwards diſtilled this reſiduum e naked fire, and he obtained at firſt ſome phlegm, afterwards id ſpirit of a citron colour, then an oil which was pretty , and laſtly a kind of coal remained, which became moiſt expoſed to the air, undoubtedly on account of the ſaline mat- hat were mixed with it.

his analyſis does not teach us much. But ſeveral modern che- have publiſhed their experiments on milk. As their diſcoveries

consist of facts, none of which ought to be neglected; as these chemists do not perfectly accord as to the facts they mention, and as a very distinct account of these discoveries is given in the *Journal de Medicine* for *March* 1773, by M. *Rouelle*, I will here add that article.

"Whey (prepared without cream of tartar) when evaporated nearly to the consistence of a syrup, and exposed in a cold place, yields crystals which are the *salt* or *sugar of milk*. The liquor in which these crystals are formed, being decanted, then evaporated a second time, yields more crystals, which are still the salt of milk. The remaining liquor may be a third time evaporated, and a new crystallization may again take place. This last salt contains some crystals of the febrifugal salt of Sylvius, and no common marine salt.

At last, a kind of mother-water remains, or coloured liquor, composed chiefly of mucus, by means of which it frequently becomes a jelly. It contains also a portion of extractive matter.

Two gros of this mother-water, diluted in twice its quantity of distilled water, did not in any respect alter the colour of syrup of violets.

If a dilute acid be poured upon this mother-water, no sensible effervescence happens.

If, upon the last crystallizations of the salt of milk, or upon its mother-water, a strong vitriolic acid be poured, a slight effervescence is excited, and vapours of marine acid are raised. This acid evidently owes its origin to the febrifugal salt of Sylvius abovementioned.

A pound of salt or sugar of milk, being distilled in a retort, yields first, a little phlegm; secondly, an acid; thirdly, an oil; fourthly, a caput mortuum, or bulky coal remains in the retort, perfectly resembling the coals which are produced in the distillation of mild saccharine mucous substances, as honey, manna, starch, sugar-candy, &c. This coal has not the properties of a fixed alkali, and does not effervesce with acids, as the coal of tartar does.

This calcined coal left very little ashes, scarcely the weight of half a gros. These were also very black, and consequently contained some coal not perfectly calcined.

These ashes lixiviated with an ounce of distilled water, changed the colour of the syrup of violets to a green. When mixed with acids, no effervescence was occasioned. These ashes therefore contain only an exceedingly minute quantity of fixed alkali.

The products of the distillation of this salt of milk are then very like those of starch and of sugar-candy.

I burned in an iron dish a pound of this salt of milk. From the coal, when thoroughly calcined, I obtained only twenty-four grains of ashes; and these ashes gave no more fixed alkali, than those did which

h were procured from the caput mortuum of the diſtillation of
f milk.

he latter cryſtallizations of the ſalt of milk, and its mother-
r being burnt, and their aſhes lixiviated, yielded a little febriſu-
lt of Sylvius, and a very ſmall quantity of fixed alkali, which
ars to me to have proceeded from the ſmall quantity of extrac-
matter that is contained in the mother-water, as is already
ioned.

pound of the ſalt or ſugar of milk that is commonly ſold, being
t in an iron diſh placed over a good fire, the ſalt melted in ſome
e, and acquired the colour of burnt ſugar. It exhaled a ſmell
ly like that of honey, manna, ſtarch or ſugar, while theſe
ers are burning.

this combuſtion, the ſalt of milk ſmells nearly as ſtrong as ſugar
; which property all ſweet ſacharine bodies have. The coal
h remains after the ceaſing of the flame, if it be kept red-hot
a ſmall blueiſh flame; which effect may alſo be obſerved in
.

he aſhes which reſult from a pound of ſalt of milk, weigh from
ty-four to thirty grains, and are ſtill blackiſh.

heſe aſhes lixiviated in an ounce of diſtilled water, give a
colour to ſyrup of violets, but occaſion no effervescence with
, becauſe the alkali is in too ſmall a quantity.

burned alſo a pound of ſugar-candy in a new iron diſh. This
r melted more perfectly than the ſalt of milk had done. The
e which it yielded did not appear more conſiderable, nor did it
onger.

he coal which remained after the flame had ceaſed, when kept
hot, burns like other coals, with a ſlight flame unaccompanied
ſmoke.

his coal when reduced to blackiſh aſhes, weighed from twenty-
to thirty grains. Theſe aſhes are very ſlightly alkaline, and
their bulk we may judge of the ſmall quantity of alkali which
contain.

t appears then that ſugar-candy gives nearly the ſame products
alt or ſugar of milk. When I ſay nearly, the reaſon is, that I
not ſee any certain difference, either in the quantity of aſhes, or
fixed alkali.

n fact, the ſalt of milk approaches nearly to the ſtate of ſugar-
dy. One part of water is required to diſſolve two parts of ſugar-
dy; and in order to diſſolve ſugar of milk, a little more than an
al quantity of water is required. I do not know any other mat-
in the vegetable kingdom, to which the ſalt of milk is more ſimilar.

evaporated and dried, in an iron veſſel, twenty-five French
nts (each pint being equal in meaſure to two pounds of water) of
's milk, and I heated it ſo much as to [illegible] When the
flame

flame ceased I reduced the coal into ashes. These ashes being carefully lixiviated, I evaporated this lixivium to dryness, and I obtained a saline matter, which weighed nine gros and 48 grains.

I examined this salt with much attention, and found that it contained not more than a gros and a half or two gros of fixed vegetable alkali, of the nature of the alkali of tartar.

The rest was a true febrifugal salt of Sylvius. Vitriolic acid being poured upon this salt, the marine acid was disengaged, and vitriolic tartar was formed.

I decomposed some of this salt by the nitrous acid, and thereby a true nitre was formed.

I ought to observe, that the milk on which, or on its products all my experiments were made, was taken in the months of December and January. We might suspect that milk taken the summer months ought to yield very different products from that which is taken in winter: But without foundation. The salt of milk which is made for sale is brought from Switzerland, and is prepared only in summer. Its analysis, as above-described, shews that the summer-milk yields no more fixed alkali than that which is procured in the winter months.

When I estimate the quantity of fixed alkali obtained from milk at two gros, which is the utmost it can be estimated at, it appears that a French pint of milk yields five grains and a half of alkali. When we consider how much of this alkali is carried off in making butter or cheese, it will appear that the quantity remaining in whey, ought to be no more than results from the above trials. We find an analysis of the whey of cow's milk in Mr. *Beaume*'s Manual of chemistry. This analysis has been objected to mine, as invalidating my experiments. M. *Beaume* has indeed obtained after a third evaporation and crystallization of whey, some crystals of ordinary marine salt. He found afterwards in the mother-water, or the liquor which cannot be further crystallized, a fixed alkali which is obtained without combustion. He also distilled some salt of milk, and the residuum in the retort was (says he) a fixed alkali. Lastly, M. *Beaumé* adds, that sugar of milk has many properties in common with cream of tartar, excepting that it is not acid.

As this analysis, which is also found in his Elements of Pharmacy, is contradictory to mine, I think it is proper to transcribe it at length, that the public may repeat the experiments, and determine upon the subject.

"Cow's whey, three fourths of which having been evaporated, yields at first a salt that has a sweet sacharine taste, and which is therefore called salt or sugar of milk. This salt is obtained by the first crystallization. The most concentrated acids have no sensible action upon it. This salt is nevertheless saponaceous. If it be exposed to the action of fire in a retort, some empyreumatic oil is obtained.

rained; and the residuum is a fixed alkali. This sugar of milk s besides many properties in common with the cream of tartar, cepting that it is not acid.

"When the liquor is again evaporated, it yields by crystallization alt nearly similar to the preceding. But the mineral acids de-mpose it. The third evaporation of whey yields crystals of com-on sea-salt. Lastly, a liquor remains which will not crystallize: contains some fixed alkali and a small quantitity of extractive tter. This fixed alkali is obtained without combustion.

"Each pint (French measure) of cow's whey, contains about ven or eight gros of the salts above-mentioned.

"We have reason to conjecture that all these salts come originally m the vegetables with which animals happen to be fed, and ich have not changed their nature by passing into the ani-l body."

uch is the result of the labours of two of our most able chemists. *Paerner* quotes in the notes which he adds to the German trans-ion of the Dictionary of Chemistry, a dissertation of M. *Vulga-z, de Sale lactis essentiali. Lugd. Batav.* 1756. As I have not en able to procure this work, I shall only mention after M. *Pær-*, that M. *Vulgamoz* gives an analysis which he made of the salt milk, and says, that the properties which he observed, shew that s *salt is saponaceous, unites oils with water, and is analogous to the t of sugar-canes.*

NICKEL. Nickel is a metallic substance, the discovery of ich was published by Mr. *Cronstedt*, a celebrated Swedish mineral-ist in two memoirs inserted in the acts of the Academy of Scien-at Stockholm, for the years 1751, and 1754.

This matter is the regulus of a very compound mineral, which s believed to contain copper, although nobody had been able to tract any from it: Hence the German metallurgists had given it e name of *Kupfer-nickel.* This mineral is found in several Ger-n mines, and probably in those of other countries, although it is re. The colour of this mineral is sometimes grey, and sometimes hining yellowish red.

Some metallurgists, especially *Henckell* and *Cramer*, have refer-d kupfer-nickel to the cupreous and arsenical ores. Mr. *Cron-dt*, after a more particular examination of it, maintains that this ineral contains a metallic matter peculiar, and different from all ose hitherto known, to which he gave the name of *regulus of nickel*, simply that of *nickel*, under which name it is now known.

Although most chemists have adopted Mr. *Cronstedt*'s opinion ncerning the substance, some however continue to maintain that pfer-nickel contains copper, cobalt, iron, and arsenic. It appears be certain that this mineral, and even the regulus, until it be rified by laborious and difficult processes, does contain some co-

balt,

bait, ſome arſenic, and alſo iron; but we ſhall ſoon ſee, that although copper may be found in ſome kinds of kupfer-nickel, the moſt deciſive chemical experiments have not been able to ſhew the preſence of any part of this metal in any of thoſe kupfer-nickels which have been ſubmitted to the moſt rigorous, and moſt judicious docimaſtic analyſis.

The experiments of Mr. *Cronſtedt* had ſufficiently proved that the ore of nickel was not a copper ore, and that the metallic ſubſtance obtained from it was either a new ſemi-metal, eſſentially different from thoſe before known, or, at leaſt, a particular allay of ſeveral metals which it is very difficult to diſtinguiſh and to ſeparate. Mr. *Cronſtedt* not having puſhed his experiments far enough to purify perfectly the regulus of nickel, our knowledge of the true nature of this regulus was but little advanced. We ſhall, in fact, ſee, that notwithſtanding the later reſearches, much more conſiderable and extenſive than thoſe of Mr. *Cronſtedt*, doubts ſtill remain on the nature of nickel; and as it has been ſhewn, by theſe experiments, that what was conſidered by Mr. *Cronſtedt* as very pure nickel, was very far from being really ſo, it follows, that we cannot depend on the reſults of the experiments concerning the allays which Mr. *Cronſtedt* relates in his two memoirs, and that theſe reſults have been prematurely inſerted in ſome modern books of chemiſtry, particularly in the Engliſh edition of the Dictionary of Chemiſtry, in the notes ſubjoined to which, many excellent things are contained.*

This nickel, which Mr. *Cronſtedt* had but in a manner announced, would have remained among thoſe many ſubſtances which are but imperfectly known, and concerning which we ſhould not have been able to have formed any diſtinct idea, if two excellent chemiſts had not publiſhed very lately the moſt extenſive reſearches that ſeem poſſible to be made on this ſubject. Theſe numerous experiments are related in a diſſertation in the form of a theſis, entituled, *Diſſertatio chemica de Nicolo, auctore Johanne Alzakio Arvidſſon. Upſali.* As all the reſources of chemiſtry appear to have been exhauſted in this excellent memoir, in order to attain an accurate knowledge of Nickel, I ſhall extract from it what appears to me of the moſt importance, although this analyſis is not perfectly complete, the mineral not having been examined in cloſe veſſels. As Mr. *Arvidſſon*'s intention was however rather to examine the regulus of nickel than the mineral itſelf, his examination

* See the *note* referred to at the article NICKEL.

this regulus may be considered as a very good model for ch researches. †

This chemist employed the common process used in essays, as r. *Cronstedt* had done, to obtain the regulus from the mineral *ofer-nickel*, which was previously well roasted, so that by the ex-lsion of the sulphur and arsenic, it suffered a diminution of weight ual to thirty per cent. The colour of the calx was green, and s the more intense as it was richer in regulus.

By fusing these calxes, according to the usual process, in a cru-le exposed to the violent heat of a forge, with a mixture of three rts of black flux, and a sufficient quantity of decrepitated sea-salt cover the whole, Mr. *Arvidsson* obtained buttons of different ights according to the richness of the minerals employed, but ceeding half the weight of the crude ore. The scoria was brown black, and sometimes blue.

Such was the regulus of nickel that was examined by Mr. *Cronstedt*. t the further experiments of Mr. *Arvidsson* proved that the kel obtained by this process was very far from the degree of rity to which it must necessarily be brought, although not with-t considerable difficulty, to enable us to determine its nature. his perfect purification is so difficult, that although the very long moir of Mr. *Arvidsson* contains nothing but the results of a very nsiderable number of experiments of all kinds made for this pur-se, we cannot with certainty say that it has been entirely attained. The first attempts of purification made by Mr. *Arvidsson* consisted long continued calcinations of a regulus of nickel of *Suabia*, hich had been prepared by Mr. *Cronstedt* himself, and in the re-ction of this regulus after each calcination. Each of these suc-ssive calcinations lasted from six to fourteen hours; they were peated six times, and they expelled from this pretended regulus va-ours of arsenic, and also white vapours which had not an arsenical ell: and after all these calcinations, in several of which powder charcoal had been added, which method is known to be very fectual to facilitate the expulsion of arsenic, the metallic buttons oceeding from the reductions, and whose weight was diminished each operation, did nevertheless emit an arsenical smell, and ere attracted by the magnet. Six successive fusions of this same gulus, with quicklime and borax, after it had undergone the bove-mentioned successive calcinations and fusions, left a metallic utton, surrounded with the quicklime which had acquired a green-h colour, and under a hyacinthine-coloured scoria. This button was

† Although I mention Mr. *Arvidsson*'s name only, because he is the uthor of the thesis it is however probable that Mr. *Bergman* directed the perations.

was still capable of being attracted by the magnet, was semi-ductile and tough, and when broke, it appeared to consist of a striated texture.

Lastly, in order to terminate this long and toilsome work of purification by calcinations, reductions, and fusions, Mr. *Arvidsson* calcined a seventh time, during fourteen hours, a metallic button which had already undergone all those proofs, till by adding powder of charcoal, no more arsenical fumes were exhaled, and no further diminution of weight was occasioned. The calx which was produced by this latter operation, had a ferruginous colour mixed with very slight traces of green, and after the reduction of this calx, a very small globule remained in the scoria which was much charged with iron, and this globule was still attracted by the magnet.

Mr. *Arvidsson* was not satisfied with making these trials on a single kind of nickel, but he tried several kinds from different countries, and the results have always been the same, that is to say, a metallic button has been obtained which was attracted by the magnet, and which consequently contained iron.

The obstinacy with which iron remained united with these metallic buttons, notwithstanding the means employed to purify them, suggested to Mr. *Arvidsson* the idea of trying other processes, and particularly by intermediate substances. Of these substances, sulphur being one of the most efficacious to separate iron from other metals, has been tried in repeated fusions, and added at four different times, without rendering the regulus, when freed from the sulphur, less capable of being attracted by the magnet.

The essays made by means of liver of sulphur, were not attended with more success.

Neither was the iron separated more effectually by the long detonations, calcinations, fusions with nitre, either of the ore or of the regulus of nickel.

These experiments did only shew that nitre is capable of discovering the presence of regulus of cobalt in nickel, although it did not appear by any other mode of trial.

Mr. *Arvidsson* had no more success in endeavouring to deprive this regulus of the iron which it contains, by sublimation with sal ammoniac, which in many substances is an efficacious method. The buttons which remained after these repeated sublimations with large quantities of sal ammoniac, were indeed only weakly attracted by the magnet, but were nevertheless sensibly attracted. A remarkable circumstance was observed, which was, that although the weakness of the magnetism of the regulus, which had been thus treated, seemed to shew that a considerable quantity of iron had been separated from it by sal ammoniac, the flowers did not however appear to be martial, being white, and not producing a black colour when added to an infusion of galls. But in these experiments, these

re was always a portion of saline matter which appeared, that
less volatile than pure sal ammoniac, and was tinged by iron
hyacinthine colour. At each sublimation, some volatile alkali
sed at first into the receiver, then some undecomposed sal ammo-
; and lastly, a little acid of salt, as generally happens, when sal
moniac is treated with most metallic substances.

Lastly, the solutions by the nitrous acid, the precipitations, and the
on of caustic volatile alkali, all these means employed by opera-
s repeated each of them five or six times, have been insufficient,
ffect a compleat purification of nickel, and especially a compleat
ration of the iron. It appears even from Mr. *Arvidsson*'s expe-
ents, that the more the regulus was purified, the more hard, te-
ious, and more difficultly fusible it became, and it acquired more
he properties of iron. Accordingly this good chemist concludes,
reason, that the perfect purification of nickel cannot take place
any means hitherto known; that the sulphur can scarcely
separated from it, by repeated calcinations and dissolutions; that
arsenic is more firmly united with it, although it may be expel-
by means of powder of charcoal and of nitre; that cobalt
eres even more powerfully than the preceding substances, since
e discovered it in some products in which it could not be ren-
d sensible by any other methods; and lastly, that the quantity of
cannot be diminished but in a certain degree, since the magnet
acted the buttons that were purified as much as they could
A very remarkable magnetic phenomenon happened in one of
*Arvidsson*'s experiments, which is, that a regulus purified by
hur, and brought by repeated calcinations and reductions to be
ost as ductile and refractory as pure iron, had acquired in these
rations such a magnetism, that it was not only very capable of be-
attracted by the magnet, but was really become a magnet itself,
se parts mutually attracted each other.

The very probable conclusion that Mr. *Arvidsson* draws from his
rious examination of nickel, is that this metallic matter is no-
g but iron in a particular state, by means of which it differs from
other kinds of iron. He thinks that this metal is susceptible of
erent modifications, which appear to make so many kinds of
als. According to this chemist, cobalt itself, the load-stone,
the regulus of the black load-stone are nothing else but nickel,
modifications of iron. He supports his opinion upon reasons so
sentaneous with many chemical facts well ascertained, that I
l here transcribe, from the French translation of his memoir,
at he says on the subject.

"We know in general, says Mr. *Arvidsson*, that the qualities of
ron vary in a singular manner, on account of the different quan-
ities of phlogiston that it contains. How many kinds of iron and
teel there are! And we ought not to forget that cobalt, the load-
"stone

"ſtone and its regulus, as well as nickel, cannot be perfectly de-
"prived of iron, but that alſo they become more ductile, more at-
"tractable by the magnet, and more refractory. Laſtly, iron
"exhibits the different colours which theſe metallic matters acquire,
"either in the dry, or in the humid way. Cobalt and the load-
"ſtone give a red colour to acids; the load ſtone ſhews this colour
"even in glaſſes. Nickel, and the load-ſtone, being melted with
"borax, give a hyacinthine colour. A green colour is obtained
"from nickel diſſolved in acids, from its calx, from the black load-
"ſtone well calcined, and alſo from its ſcoria when reduced by
"means of the white flux. Laſtly, cobalt gives to glaſs a blue
"colour, or rather a violet, and the load-ſtone gives a ſimilar colour
"in fixed alkali, and nickel in volatile alkali.

"Iron preſents all theſe varieties. When diſſolved in acids, it
"communicates to them a green colour, which laſts while the me-
"tal retains a certain quantity of phlogiſton, whereas they become
"yellow, red, or of a reddiſh-brown, according as the quantity of
"the phlogiſton diminiſhes. It alſo tinges glaſs of a green, yellow,
"black, or red colour. If it be calcined with nitre during ſeveral
"hours, the bottom and ſides of the crucible are covered with fa-
"line flowers of green, blue, or of a purple colour. This efflore-
"ſcence ſcarcely colours water, and like iron, communicates to
"glaſs a greenneſs which vaniſhes by cooling. Whence it appears
"that this colour which we obtained from nickel, by means of
"nitre, was chiefly produced by iron. It is to iron that the green
"colour of nephritic and ſerpentine ſtones, jaſpers, clays and other
"earths is owing. It is that which tinges ſeveral blue ſtones and
"alſo ſeveral varieties of yellow and red."

All theſe facts added to a great number of experiments, give certainly much probability to the opinion ſuggeſted by Mr. *Arvidſſon*; but we muſt not thence conclude that there are really ſeveral kinds of iron eſſentially different from each other. There is but one kind of iron, as there is but one kind of each of the other metals; nevertheleſs iron, as Mr. *Arvidſſon* well obſerves, may by the greater or leſs quantity of phlogiſton which it may contain, or by certain allays which it may contract, and from which it has not been hitherto diſengaged, be preſented in ſuch ſtates or forms that it might not be diſcovered, if its magnetiſm was not a certain mark by which it may be known.

The other metallic and mineral ſubſtances which Mr. *Arvidſſon* conſiders as ferruginous, are probably only matters which conſiſt of iron differently allayed and diſguiſed. Meſſrs. de *Baſſus* and de *Milly* think that *platina* ought to be put into this claſs. *Manganeſe*, and ſeveral other minerals, whoſe nature is but imperfectly known to us, will probably augment the compounds of this

kind

d, if we make as accurate analyses of them as Mr. *Arvidsson* has
e of nickel.

That no mode of inquiry might be omitted, Mr. *Arvidsson* also
ployed that of Synthesis, that is, he endeavoured to compose an
ficial nickel by combining the different substances which he had
nd from analysis to be contained in this compound and nearly in
same proportion. But although the experiments which he
le with this view are very curious and interesting, I shall not
e an account of them in this place, left I should extend this ar-
e to too great a length, and because they did not perfectly satisfy
expectations of the author; which will not appear surprising
hose who have been accustomed to such trials, and who know
n experience how difficult it is to imitate perfectly the combi-
ions which are made by nature.

Ve shall conclude this article by mentioning the properties which
. *Arvidsson* observed in the nickel that he had brought to the
atest degree of purity that he could. As to the properties of
kel as related by Mr. *Cronstedt*, they do not deserve any consider-
n, the regulus he obtained having been a very impure allay.

According to Mr. *Arvidsson*, the specific gravity of nickel is to
t of water, nearly as 9000 to 1000.

t appears that the more pure nickel is made, the more it ap-
aches to the tenacity, malleability, infusibility, and magnetism
ron: At the same time it becomes more fixed and more difficult
e calcined, and the more green its calx becomes. It is soluble
cids. The vitriolic acid attacks its calx, with which it forms a
en salt contained within ten sides, the crystals of which are simi-
to those of alum flattened and truncated at the two opposite
remities. The acid of nitre dissolves with difficulty this calx of
kel. The marine acid, and also most of the vegetable and ani-
l acids which Mr. *Arvidsson* tried, dissolved more or less easi-
nickel or its calx, and these solutions are green or inclined
re or less to this colour. Alkalies, both fixed and volatile, at-
k also this metallic matter, the fixed in small quantity; and the
ution made by fixed alkali is yellowish, while that of volatile al-
i is always blue.

Nickel, although it is almost as difficult to melt as forged iron is,
en it is purified as much as is possible, enters easily into fusion
h other metals. But Mr. *Arvidsson* confesses that the quantity of
kel which he was able to purify sufficiently for these allays, was
small to permit him to make all the requisite experiments on
s subject. In general he observes, that impure nickel cannot
tract any union with *silver*. It is principally the allay of cobalt
h nickel that resists this union. For Mr. *Arvidsson* having tried
with nickel which he had purified from cobalt, found that it
ld be easily united with silver, in equal parts, without producing

a

a great alteration in its whiteness, or [illegible] municated to borax a hyacinthine colour, [illegible]

*Copper* unites more difficultly with nickel [illegible] theless forms a reddish ductile mass, from [illegible] a glass of a bloody-hyacinthine colour.

With equal parts, or even with a larger [illegible] gives a brittle mixture; in which respect [illegible]

Mr. *Arvidsson* could not amalgamate nickel [illegible] means of trituration. When well purified, [illegible] produces a brittle allay.

The hyacinthine colour, more or less [illegible] calxes of nickel, especially those made by means [illegible] nicate to glass, may be weakened, or made to [illegible] lour produced by manganese may, and the [illegible] restoring the colour is by addition of nitre.

## *Addition to the Article* NITRE *of the* [illegible]

THE opinion of *Stahl* concerning the [illegible] namely, that it is nothing but the universal [illegible] altered by combination with the phlogiston of [illegible] has been adopted by many, and among these, by Dr. [illegible] supports this opinion by several proofs and by [illegible] which an account is given in a memoir that obtained the prize of the academy of Berlin.

Several chemists, among whom is *Glauber*, have pretended that it is the marine acid that is changed into the nitrous, and have affirmed that they know the means of this transformation. But these promises have never been realized.

It is needless to relate here all the hypotheses which have been formed concerning the origin and the production of the nitrous acid, as they may be found at full length in the collection printed by order of the commissaries appointed by the academy of sciences, to adjudge the prize for the best researches on the method of making salt-petre, for the year 1785. We have reason to believe that after this prize has been adjudged, and the researches of the several competitors, as well as of the commissaries themselves, who have undertaken a very complete set of experiments on this subject, we shall be able to form more just and precise ideas than before on the important question concerning the origin of the nitrous acid.

As I have the honour to be one of the commissaries, and so I have had thereby an opportunity of knowing the memoirs which have been sent, as well as the experiments in which the academicians, who are to adjudge the prize, are engaged, I could now insert here a part of the important discoveries that will result from these researches; but as these inquiries are not yet finished, and as the

e authors and their discoveries ought to remain unknown, till the ize has been adjudged, I find myself under the necessity of being ent upon this subject.

I shall only say, that the sole matters capable of the putrefaction, hich produces nitrous acid, are the substances which compose the dies of animals and vegetables, especially the former, and which erefore seem to deserve the preference. Nevertheless, a consider-on of some importance teaches us not to exclude vegetables inthe king of nitre. For experience shews that the nitre which results m the putrefaction of substances that are purely animal, is no-ng but a salt-petre with an earthy basis, to which it is necessary add a basis of fixed alkali in the subsequent operations, to trans-m it into a crystallizable salt-petre, fit for the purposes for which s used; whereas the nitre to the production of which the putre-tion of vegetable matters has concurred, is found to be furnished turally with the quantity of fixed alkali that is necessary, in der to make good salt-petre. It appears then, that the mixtures st fit for the production of salt-petre, are those which contain rly as much vegetable as animal matters.

But it is not sufficient merely to accumulate these putrescible tters in large masses and to let them remain, in order that nitre ould be produced. If that were sufficient, the matter of houses office ought to contain an enormous quantity of nitrous acid. t this matter, however old, is not found to contain any, when it aken out of the pits. The reason is, that the putrefaction is not mpleated. It frequently happens, that this matter, although 50, , or even a hundred years old, is found to have as fetid a smell, en taken out, as if it were only three or four years old. The se of this want of compleat putrefaction can be nothing else n the want of air. The event is very different, when these tters, or any others susceptible of putrefaction, are divided and tributed in porous earths which are in contact with air. The trefaction and total decomposition which then follow, happen much more speedily, as the putrescible matters are dispersed a-ng the porous earths in less quantity, and are therefore so much re exposed to the immediate contact of the air. Accordingly it observed, that the earths of this kind which are mixed with, mall quantity only of putrescible matter, are those which furnish t-petre most quickly and most abundantly; and this is a circum-nce which ought to be much attended to in the construction of re-beds.

For the same reason, the porous, friable, and aerial earths, as careous earths, are of all the most favourable to the production of re. It is a fact, that a small quantity of putrescible matter, as ventieth, for instance, being distributed in an earth of this nature, n, with the other circumstances necessary to putrefaction, be so

totally decomposed, that in one year no degree of fetid smell shall remain, and that salt-petre may be then extracted from the mixture.

But as the quantity of salt-petre will depend on the quantity of putrescible matter that has been totally decomposed, and as the conditions necessary to putrefaction are well known, it is easy to deduce from thence the best methods of producing in putrescible mixtures, the quickest or the most copious nitrification that is possible.

These conditions are in general the same as those of all kinds of fermentative movements, that is to say, a continued heat from 25 to 30 degrees of *Reaumur*'s thermometer, an habitual moisture, and above all, the free access and contact of air, in order to compleat the putrefaction. To these circumstances must be added the requisite shelter, to prevent the rain from washing away the putrescible matter, or the nitre as soon as it is formed. I make not the least doubt that nitre-beds may be formed, which may yield much larger quantities of nitre, than any that have been yet made.

Upon these principles, it follows that as earths do not serve to any purpose but to divide the putrescible matters, and to accelerate the completion of the putrefaction, by facilitating the access and the contact of the air, they are not necessary to the process of making nitre; and other matters less weighty and bulky, may perhaps be substituted in their place to advantage; such as small sticks, fagots, bark of trees, all which might be strongly impregnated with the most common animal matters as excrements, and accumulated in heaps that are very considerable, and at the same time permeable by the air. It would be easy to keep up in these heaps a proper degree of moisture, either by watering them or by placing them in humid subterranean places. The laborious manœuvre of stirring and exposing to the air all the surfaces of the putrescible matters, would in this case be unnecessary. The most expensive circumstance would be to keep up an habitual heat of about 30 degrees of *Reaumur*'s thermometer. If the operation was required to go on speedily, stoves would be necessary in this climate, during eight months of the year: But the greater produce would perhaps amply compensate this expence. Moreover, although all appearances are in favour of the success of this kind of mixtures treated in the manner I have mentioned, I cannot absolutely warrant its success, because I have not yet made the experiment of it, nor do I know that it has been made by any other person.

But to return to what has been long known concerning nitrous acid, I shall observe that it is not found disengaged, but as fast as it is formed, it combines with such matters as it can dissolve, and as are found within its reach. Thus it is sometimes found united with a fixed alkali and forms consequently ordinary nitre, such as the nitre found in plaster or formed by the putrefaction of vegeta-

bles.

es. But it is most frequently combined with absorbent earths, cause it generally meets with these earths in the places where it formed in greatest plenty. It is therefore commonly found under e form of *nitre with earthy basis*.

There are some earths in which a considerable quantity of salt-tre is habitually formed, well crystallized and with a basis of fixed tali, and may be obtained by a simple lixivium, without any addi-n of ashes or of fixed alkali. The Duke of *Rochefoucault* observed great deal of this kind of earth forming a stratum of several lines in cknes, upon the surface of the rocks of chalk, in the environs of *Rochegusyon*. A remarkable circumstance is that the nitre is never ind with a basis of fixed alkali, but in the neighbourhood of inha-ed places, as Mr. *Lavoisier* observes, who also visited these rocks: hereas the nitre that the *Duke of Rochefoucault* procured from ese chalks whether on the surface, or at considerable depths, in ces at a distance from any houses, was constantly found to have basis of calcareous earth. There is reason to hope, that the *Duke Rochefoucault*, M. *Bucquet* who was also concerned in these obser-ions, and M. *Lavoisier*, will publish the researches which they ve made upon these earths. They cannot fail of being very eresting.

According to Mr. *Bowles*, in his *Introduction to the Natural History l Geography of Spain*, the nitre which is obtained in large quan-ies in several parts of that kingdom, has also a basis of fixed kali. But far from concluding from thence, against all probabi-y, and even against the best attested facts, (as Mr. *Bowles* does) at the fixed alkali of this salt-petre, as well as its acid, are habi-ally formed without the acid of animals or vegetables; no chemist ll make any other deduction from this fact, than, that as in hot mates the putrefaction of vegetables happens in less time than in ld climates, those plants, from whose decomposition the nitrous id is formed, do also yield a portion of the fixed alkali that is ne-ssary to constitute it perfect nitre. I say a portion, because it is robable, that in these lixiviums of nitrous earths in Spain, there also a considerable quantity of salt-petre with earthy basis, which lost, because no ashes nor fixed alkali are mixed with it. This nnot be ascertained from Mr. *Bowles*'s account, because he has ot made any experiments on this matter.

Another fact pretty remarkable is, that certain kinds of ashes hich contain little or no fixed alkali, such as the ashes of the amarisk, do however, when added to nitrous lixiviums, contribute much to the production of a salt-petre with basis of fixed alkali, the ashes that are the most rich in alkali. This fact is certain, nd has been verified by M. *Tronson du Coudray*, an officer of the tillery, Correspondent of the Academy of Sciences, and distin-uished by his knowledge in chemistry. This would seem to prove

that the addition of fixed alkali is unneceſſary in the lixiviation of nitrous earths. But this is only a deceitful appearance. The matter may be thus explained. There are in fact ſome kinds of vegetables whoſe aſhes contain little or no diſengaged fixed alkali. But they are nevertheleſs filled with vitriolic neutral ſalts with baſis of fixed alkali; and it has been aſcertained by ſeveral chemiſts and eſpecially by M. *Lavoiſier* and myſelf, that nitre with baſis of calcareous earth and neutral vitriolic ſal s with baſis of fixed alkali do mutually decompoſe each other by means of a double affinity; that is to ſay, that the vitriolic acid of vitriolated tartar, or of Glauber's ſalt, is transferred to the calcareous earth of the nitre with earthy baſis, with which it forms a ſelenites that precipitates; while on the other ſide, the nitrous acid unites with the fixed alkali thus abandoned by the vitriolic acid, and thus becomes a ſalt-petre with baſis of fixed alkali, no leſs perfect and cryſtalliſable, than if to the nitrous lixivium had been added the quantity of diſengaged fixed alkali that is neceſſary to the total decompoſition of all the nitre with earthy baſis that it contained.

We may eaſily underſtand, from what has been ſaid concerning the generation of nitre, that the quantity of this ſalt ought to be very variable in the earth in which it is formed. In general, it is not very conſiderable. There are ſome of theſe earths which do not yield more than two or three ounces per hundred weight; and the richeſt of them, which are compoſed of the rubbiſh of old houſes, do not yield more than one pound. But there is reaſon to believe that by artificial nitre-beds judiciouſly formed, that is, by a concurrence of all the circumſtances which experience ſhews to be neceſſary to the production of nitrous acid, eſpecially the acceſs of air, ſhelter from rain, the moſt favourable degrees of heat and moiſture, this production might be conſiderably haſtened and augmented.

## *Addition to the Article* PHLOGISTON *of the former Edition.*

THOSE who are acquainted with the detail of the phenomena of chemical operations, and who poſſeſs the genius of the ſcience, that is the faculty of perceiving and comparing the relations which theſe phenomena have to each other, are well convinced that the moſt pure and ſimple matter of fire, notwithſtanding its extreme mobility, may be combined with even the moſt fixed bodies; that it loſes by means of this combination, the rapid motion and other properties which characteriſe it; that this igneous principle communicates to the compounds into which it enters as a conſtituent part, the characters of combuſtible and inflammable bodies; that the combuſtion of theſe bodies and all the effects which accompany it, are produced by the diſengaging of the fire, which

paſſes

passes from the state of combination and fixation to that of liberty, and to its natural mobility; that this fire, which when combined and fixed acquires the name of phlogiston, may like other chemical agents, pass from one combination into another without becoming disengaged fire, and consequently without producing the phenomena of combustion: so that the combustible body which transmits it remains no longer combustible after it has thus parted with it, while the new body with which it combines becomes combustible, although it was not so before its union with the igneous principle. Moreover, all this theory, founded on facts as numerous as incontestable, contains nothing that seems obscure to those who know the facts, and who have been accustomed to see them. It is not so however with some other persons, who although they have never been at the trouble to understand or even to read the good books that have been published on chemistry since the revival of the sciences, that is to say, from *Stahl* inclusively, do not however hesitate to pass their judgment on them. The theory of phlogiston seems to be reprobated by them because they do not understand it, nor have the least idea of the proofs on which it is founded. A substance supposed to be material, although it cannot be confined in a pure and disengaged state in a bottle, as acids, alkalies, and other chemical agents may, appears to them to be a chimerical idea, which has no existence but in the imagination of chemists, and invented to explain well or ill a number of facts, and of obscure and embarrassing phenomena.

The most prudent conduct would be to leave these persons in their opinion without making new efforts to clear up this matter. Nevertheless, as chemistry must gain by being better and more extensively known than it is, I shall here add some considerations relating to phlogiston, the idea of which was suggested by what I have said concerning the nature of fire. The opinion which I have adopted in the article on FIRE consists in acknowledging no other igneous substance than the matter of light, and in considering heat only as a movement of oscillation or vibration, of which the aggregant and constituent parts of any bodies are susceptible, when they are shook by the impulse either of light, or of any other matter in motion. If this opinion be well founded, it necessarily follows, that heat not being a peculiar matter, but only a modification, a mode of existing of which all kinds of matter are susceptible, cannot any more than motion, enter into any combination, nor be fixed in any compound as a principle or constituent part. Accordingly *phlogiston*, or the combined fire of chemists, is not *heat*, or any thing relative thereto. But as combustible bodies produce in their combustion all the phenomena of fire, the igneous principle, to which they owe this property, can therefore be nothing else than the matter of light, which, when it is disengaged from the fetters of com-

bination, produces not only the phenomena peculiar to it, but also heat, or the movement of vibration of the particles of bodies in which heat essentially consists.

It follows from thence that the names of the *igneous principle*, *combined fire*, *fixed fire*, *inflammable principle*, or lastly, that of *phlogiston*, do express nothing else than the matter of light considered as fixt in mixts as one of their constituent parts. All the difficulty and obscurity which those who have not read and understood the works of the best modern chemists have found in the theory of phlogiston, proceed solely from this, that they have not had a clear idea of the nature of fire, and from considering heat as the same thing as fire, whereas it is only one of the effects of fire, and an effect which even is not peculiar to it, but which may be produced by any other matter, provided it be animated with a sufficient quantity of intestine motion.

Phlogiston is then nothing else but the peculiar substance of light fixed mediately or immediately in a great many compounds, of which it is one of the principles, and deprived, while in this state of fixation, of its mobility, and of the other properties which distinguish it when it is disengaged.

*Light* being acknowledged a material substance, whose motion, elasticity, retrangibility, and reflexibility are known, which may be directed, turned aside, reflected, concentrated, dispersed, &c. which may be even decomposed and recomposed, there is no more difficulty in conceiving that it unites and combines with any other kind of matter, than in comprehending that air, water, and earth are susceptible of these unions; and nobody has ever suggested a doubt that the air, water, and earth that are obtained in the chemical analysis of mixts, were combined in these mixts before their decomposition. Why should not the same take place with regard to light, a substance which is indeed possessed of a greater degree of mobility, but is no less material than water, air, and earth? Can there be any kind of matter that is not subjected to attraction, or to the general tendency of the parts of matter to each other, and that is consequently capable of contracting all imaginable unions, when nothing resists these unions? Can a matter such as light, with the curious properties of which, not only chemists but persons the least conversant in natural philosophy are acquainted, be considered as an imaginary being? When it is demonstrated by the most numerous and best ascertained facts, that this substance, to which none of the properties of matter are wanting, is really combined as a constituent part in a great many compound bodies, and particularly in combustible bodies, shall we not be permitted, to denote it by a particular name, such as that of *phlogiston*, to distinguish the portion of light which is in this state of combination and fixation, from the portion of the same matter, which not being combined, possesses all the

the mobility that characterises it in its state of liberty? Chemists convinced by multiplied and incontestable experiments, that fat, resins, bitumens, coal, metals, and, in a word, all kinds of combustible bodies, do daily form with the vitriolic acid, which is not combustible, a combustible compound called *sulphur*; and that the combustible bodies employed in this combination, lose their combustibility in proportion as they contribute to the production of a greater quantity of sulphur; have from thence concluded, that in all combustible bodies there is a matter combined, a principle to which these bodies owe their combustibility: and that it is this same matter which quits them in order to unite with the vitriolic acid with which it forms the new combustible compound.

The same chemists, after having subjected to all the imaginable proofs the sulphur which they produced in the different combinations above-mentioned, and after having ascertained with the clearest evidence that this sulphur was always perfectly the same, and absolutely *identical*, of whatever nature the inflammable body was which furnished the phlogiston, have thence concluded, that as the vitriolic acid of this compound was constant, nothing could occasion any difference but the inflammable principle; and as no difference existed in this principle, or in the sulphur thus formed, therefore this phlogiston was itself an invariable substance, always the same, lastly, quite *identical* in any combustible bodies.

This truth has been confirmed by an infinite number of other facts as certain and as decisive as the artificial composition of sulphur, and especially by the reduction of all metallic calxes. For most metals when exposed to the action of fire with the free contact of air, that is to say, with the conditions necessary to the combustion of combustible bodies, lose more or less completely their metallic appearance and properties. Some of them even burn with a very sensible flame. From these facts chemists have concluded that these compounds contained the principle of inflammability or phlogiston. They found that the earths or ashes remaining after these combustions might be again formed into metal whenever any combustible body containing phlogiston, and capable of restoring to them what they had lost was applied to them; that this combustible body employed in the reduction of metallic earths, lost its combustibility in proportion as it communicated this property to the earths thus reduced into metal. They concluded from these facts that the phlogiston had passed from the combustible bodies into the metallic compounds. Lastly, they demonstrated by the most simple and most certain experiments, that the earth of any metal, such as that of lead, for instance, never formed any other metal than lead by its combination with phlogiston; and that of whatever kind the combustible body was, the phlogiston of which was applied to reduce this calx of lead, whether it was oil, resin, fat, wood, coal, or even

some other metal, there resulted from all these combinations a lead always exactly the same without the least sensible difference. From these facts they have concluded that the principle of inflammability was a constant being, always the same, and always similar to itself, in a word, an identical being throughout all nature, in the same manner as air, water, gold, and many other bodies more or less simple or compounded, but constant, identical and invariable each in its kind. If this be not a legitimate conclusion, a conclusion which necessarily follows facts; if we are not allowed to say that a globule of pure gold is entirely similar and identical with another globule of pure gold; that a drop of pure water is the same kind of matter as another drop of the same water; that a molecule of light undecomposed is not different from another molecule of the same light; it must be acknowledged that all reasoning must cease, not only in chemistry, but also in every other kind of science or knowledge.

I have already made most of these remarks in many places of the former edition of this work, and even in the article *phlogiston*; but I must ask pardon of the attentive and intelligent readers for this repetition. But it will be acknowledged that I am obliged to it, by the following passage in a work printed in 1774.* "The same phlogiston of chemists (a being of *their method*, rather than Nature) is not a *simple* and identical principle, as they pretend. It is a compound, the produce of an allay, the result of the combination of the two elements *air* and *fire*, fixed in bodies. Without entering into an examination of the *obscure* and incomplete ideas which the consideration of this *precarious* body could suggest, let us consider our four real elements, to which chemists, with all their new principles, will be always obliged ultimately to recur, &c."

Here is a decision, which considering whence it comes, will certainly be a severe censure upon all those who have engaged in chemistry, since the renovation of the sciences, if it were merited and had been pronounced after a sufficient knowledge of the question had been acquired.

I know very well that it cannot make any impression upon those who give themselves the trouble seriously to study chemistry, and understand truly this science, and that in this respect, it was superfluous to justify it. But I know also that the number of true chemists is very small, while that of the readers of the work of the illustrious author whom I have quoted is very great, and it is certain, that these latter, who compose almost the whole of the world, and who know the name only of chemistry, must receive their

* Supplement to Natural History by Mr. *Buffon*.

n this celebrated writer, whose authority is of so great weight; l as an unfavourable impression must necessarily be the result, ich may be so much the more hurtful to the progress of science, t would be more general, I believe that it is indispensibly necess- to justify our modern chemistry from imputations so little rited.

I must therefore beg leave of the readers, and even of the illus- ous and severe censurer to whom I reply, to make some short lections, which will have no other end but to lay before him the th, and to inspire him with sentiments more favourable.

The phlogiston of chemists is represented as a *being of their me- d, rather than of nature.* Upon this we shall observe that the n *method* which used to have a favourable signification, must be e taken in a different sense, since whatever can be called *method* proscribed in the works of this writer; but we must remark, that atever idea can be annexed to a doctrine that is denoted by the pression *method*, it certainly is not applicable to the doctrines of chemists in any age. The pretended *method* of chemists does erefore exist only in imagination. For if any fault is to be found th them it must be on account of their want of method. They ver were before blamed for having any. Whoever would be at trouble to read their works, would perceive that they contain thing more methodical than the works of the philosopher who s generally blames all kinds of method. Secondly, it is said, t phlogiston *is not a simple identical principle, as chemists have re- sented.* In this charge we find an allay of truth with falsehood, ich ought to be parted. It is true that chemists do represent logiston as an identical principle, as the same being, or same kind matter, whatever be the nature of the compound bodies in which s combined. And if there be any truth demonstrated in natural ilosophy, this is certainly one, as appears from what we have d above. But it is absolutely contrary to truth that chemists ve decided that phlogiston is a simple being. They declare that ey have no certainty of the absolute simplicity of air, water, or en fire, and they have formally explained themselves on this ad. How then should they attribute simplicity to phlogiston hich can be nothing else but pure fire, or fire combined with me particular matter necessary to fix it, with some intermediate bstance by which it may be rendered capable of combining with her substances; and in this case it would evidently be a secondary inciple, or a compound body. However weak they may be sup- sed to be, this absurdity exceeds the bounds of probability. If y one will be at the trouble to read what is said on this subject in is article, he will see that the opinion maintained is that the inciple of inflammability can be nothing but either the most nple and pure matter of fire itself, or else this same matter com-

bined

bined with some particular substance which is always the same. Chemists have thus left undecided the question concerning the absolute simplicity of the principle of inflammability: but as it appears, this celebrated author has not been sensible of their conduct in this respect. He himself has however taken upon him to decide the question. He has pronounced that the principle of inflammability, *the phlogiston of nature is a compound, the result of combining two elements, air and fire, fixed in bodies.*

Although nobody is more sensible than I am of the value of the ideas of this illustrious naturalist, this opinion appears to contrary to the best ascertained chemical facts, that I find myself obliged to explain the reasons that prevent me from adopting it. I am going then to refute the opinion of a great man whom I honour. This reflection has almost stopped my pen. But can I fear that I shall trespass upon the respect due to him, if I do only use that liberty of sentiment in matters of science, of which he so well knows the rights and advantages, and which can never fail to be regulated by the rules of good-breeding, when it has no other motive than the love of truth.

Let us observe first, that if it were proved that the element of fire cannot be fixed in bodies, while it is pure and simple; that it necessarily required to be combined with another element; that this element were air: in a word, that phlogiston were a compound of air and fire: as these two substances are constant beings, each in its kind, it would follow, that the compound which they would form by their union, namely phlogiston, would be also a constant and identic being throughout all nature, and that consequently, the chemists who have represented it as identical, not from reasonings, but from a multitude of conclusive facts, of which I have made mention, would not have merited the reproach that has been thrown on them.

But this is not the principal object here. It is necessary to know what the matter of fire is, to decide what property it is known to have, which disqualifies it from entering as a pure and simple principle into the composition of other bodies, as all the other kinds of matter do: to determine whether there be only one substance capable of binding this matter of fire, and of being employed as a necessary intermediate substance to fix it in the combination of compounds. We ought further to determine if there be any of the facts known in chemistry which prove that this substance, which is thus capable of forming phlogiston by its union with the matter of fire, is *air*.

Lastly we ought to examine if all the chemical facts do not on the contrary unite to prove that the matter of fire has not occasion of any intermediate substance, or of any allay, in order to be fixed in different compounds, as one of their constituent parts, and particularly

ticularly that air does not enter into the composition of combustible bodies which contain more fixed fire or phlogiston than any other bodies. I shall make upon these different subjects the following remarks.

First, none of the properties of fire hitherto known, proves that this element is any thing but the proper substance of light. They further prove that there is nothing material in fire but the pure substance of light; and that heat is only a modification, a particular state, which is not peculiar to the matter of fire, but of which all bodies as well as light are susceptible. This proposition I believe I have proved at the article FIRE.

Secondly, I acknowledge, that before I had this idea of the nature of fire, I believed with the greatest number of Natural Philosophers, that *heat* was a real substance, a matter of a particular nature, capable of acting, as we see that fire acts upon all bodies; that in a word, heat was the true matter of fire, the most simple and pure igneous matter; and that in this false idea, not being able to conceive how this pretended matter, which penetrates all bodies without being ever fixed in any of them, could nevertheless become the principle of the inflammability of bodies, I imagined that there might be in nature a kind of matter, entirely unknown to us, which alone might have the property of uniting directly with fire, and which having thus once fixed it, was the necessary intermediate substance by which it might enter as a constituent part into the composition of combustible bodies. This, I admit, was only a conjecture, which even departed from the opinions of *Stahl*, and was solely intended to explain an unintelligible fact, of which that chemist had left no explanation. I confess further, that this conjecture on the nature of phlogiston, having been imagined merely to explain a fact which I then believed to be true, but which is not so, namely, that heat is a substance, which in certain cases and by means of some other intermediate substance combines in bodies, ought to appear so much more obscure, so much more vague, and destitute of proofs, as this substance that is supposed to be the necessary connecting matter by which fire is converted into phlogiston, was not either known, or ascertained, nor even could be assigned.

It is probable that the illustrious author of the *Introduction to the Natural History of Minerals*, found himself no less embarrassed than I was; but being bolder, and not chusing to leave any thing undecided on so important a subject, he attempted to dissipate all obscurity from it, by assigning the matter which is to serve to connect fire, so that it may be able to form the fixable fire or phlogiston; and it is *air* that he has chosen to make along with fire, not the phlogiston of chemists, but his own phlogiston, which he calls that of nature.

Our

Our opinion then did not differ but in this respect, that I did not determine what the substance was which could serve as an intermediate substance to fire, in the formation of phlogiston, and that he did determine that substance. But I ought to remark, that it was only upon the supposition that we can demonstrate that the matter of fire alone was not capable of being fixed in bodies, that I dared to imagine that an intermediate substance might be necessary, without presuming to determine what this substance could be. But if it be proved, as I believe it now is, that the most simple and pure matter of fire, which is nothing but *light*, is capable, like any other kind of matter, of combining directly in compound bodies, it is manifest, that its previous union with air or with any other particular matter, is entirely useless and supposed without any necessity. I must then abide by my first proposition, which fundamentally is the same as that of *Stahl*, namely, that phlogiston is nothing else than the most simple and pure matter of fire fixed directly, as a component part, in the combination of many bodies, and especially in that of combustible bodies. As then the pure matter of fire is nothing but light; and as none of the properties of light indicate that it is not as capable of being fixed as any other kind of matter, nothing here appears indeterminate, obscure, precarious, and we ought both of us, the illustrious author whose opinion I contest, and myself, to abandon, with a good grace, he his mixture of air with fire, and I my combination of fire with some unknown matter, to which, however, I had no resource, but conditionally; for want (I confess) of having sufficiently reflected on the nature and properties of fire, and from my having confounded them with heat. In fact, if we have occasion only to consider *light* as the sole matter of fire fixable in bodies, in order to explain all the phenomena of combustible bodies, why should we suppose any other matter with which it ought to be combined in order to render it *fixed fire*, *phlogiston*, or the principle of the combustibility of bodies? And although even this supposition were as necessary, as it appears to be useless and unsupported by proofs, what motive can we have to prefer *air* to all kinds of matter, in order to compose with fire, the principle of inflammability, or the true phlogiston of nature. Let me reflect ever so much on this subject, I cannot discover any reason of this preference given to air; and not only I do not believe that any plausible reason can be alledged, but on the contrary, it appears to me to be proved by facts, by the phenomena of *combustion*, and of *phlogistication*, that air and fire do always reciprocally exclude each other from combining in the same compounds; and that these two elements do constantly precipitate each other in these two great operations, to which every thing concerning the union of the matter of fire and its disengagement may be reduced.

The

The operation in which the igneous principle is ſeparated in the ɔſt ſenſible and expeditious manner, is combuſtion. But it is nonſtrated by facts, firſt, that no kind of combuſtion can be ıde without the concurrence and contact of external air: ſecond- that in proportion as the combuſtion proceeds, there is a dimi- tion and abſorption of the air that has concurred to this com- ſtion: and thirdly, that the part of the combuſtible body which nains after the burning of it, contains as much air combined and ed, as there had been air employed in the combuſtion of that dy. Is it not manifeſt from theſe eſſential circumſtances of com- ſtion, that the phlogiſton or fire fixed in the combuſtible body is parated from it merely by the action of the air, which takes the ıce of the phlogiſton, as ſoon as this principle is diſengaged and comes fire, and conſequently, that air is the decompoſing me- ım, or true precipitant of the matter of fire?

The operation in which the igneous principle is combined in the ɔſt ſenſible and expeditious manner, is the reduction of the rths or aſhes of metals, into a metallic ſtate. But it is now de- onſtrated, by the moſt deciſive experiments, that theſe metallic rths or aſhes, which are the reſiduums of a true combuſtion of etals, are, as well as the aſhes of all other combuſtible bodies, arged with all the air that had ſerved to the diſengagement of their ılogiſton; that their augmentation of weight is owing to this r which is thus combined in place of the diſengaged matter of re; and laſtly that they can never be re-eſtabliſhed in their me- llic ſtate, by reſtoring to them the matter of fire, unleſs the air ıat was fixed by means of, and during, the combuſtion, be diſen- aged in proportion as the matter of fire is re-combined with them nd reſumes its former place by this reduction, which is really the ppoſite operation to combuſtion. And as no metallic reduction an take place without the concurrence and contact of the matter f fire, and as a diſengagement of air and a proportionable dimi- ution of the weight of the metallic calxes in every reduction actu- lly happen; is it not evident, that the matter of fire does in this aſe ſeparate the air combined in the aſhes of the metal, and re- ume its place, while it is thus again combined, and conſequently ecome the decompoſing medium of the *aerial earthy* mixture, which t changes and reduces, by means of its own union, into another *gneous earthy* mixture, that is to ſay, into metal: and laſtly, from ll theſe facts, now rendered inconteſtable, ought we not to con- lude, that, ſo far from the matter of fire wanting the concurrence nd mixture of air in order to fix it in bodies, and to become the ɔhlogiſton of nature, theſe two elements have a kind of incompati- ɔility, ſince they expel each other reciprocally, and ſince one of hem cannot be fixed in any body without at the ſame excluding he other?

Notwith-

Notwithstanding the force of these considerations which seem to prove evidently, that phlogiston is not and cannot be the result of a mixture of fire and air; I confess, that if we knew any facts which could prove that the principle of inflammability is nevertheless the result of such a mixture, these proofs or matters of fact, which ought to be positive and direct, ought to be preferred to those which I have alledged. If, for instance, we could not decompose any combustible body so that it should not remain in any degree combustible, without a quantity of air disengaging itself at the same time proportionable to the quantity of the matter of fire which should have been separated from it; and reciprocally, if in all the operations, in which the matter of fire enters into a compound, it were proved, from the circumstances of these operations, that a new portion of air does also enter into the same combinations, it would be natural to conclude, that the air is an intermediate substance by which the matter of fire combines and fixes in bodies. But I maintain, that no such fact can be adduced; and I appeal to the testimony of all those who are acquainted with the detail of chemical operations.

For, let any combustible body, (excepting fur-compounds, such as wood, bones, &c.) be subjected to any analysis or decomposition, without excepting even combustion, we shall never obtain any air in these decompositions. The reason, why fur compounds ought to be excepted, is, that their analysis shews, that besides their constituent oily part, to which alone they owe their inflammability, they contain also other proximate principles, from which a great quantity of air may be obtained. But these latter principles, which are chiefly of an earthy nature, do not possess in themselves any combustible quality. We must not then class among combustible bodies, any but those which in fact are so of themselves, that is to say, those in which the matter of fire is really a constituent part, and which cannot be entirely decomposed, without the igneous principle being disengaged from their combination, either by the combustion which renders it totally free, or by the change which makes it pass into a new compound of another kind: in both cases, what remains of the combustible body that has been decomposed by the separation of the phlogiston, ought to be, and is, in fact, incombustible; but with this difference, that when it happens in consequence of a change produced, the body in which the matter of fire combines from being incombustible, is rendered by this new union, combustible; which effect ought necessarily to take place, and does very sensibly happen in the artificial composition of sulphur, in metallic reductions; in a word, in all operations where there happens a similar translation of the principle of inflammability from one compound into another.

There

These unequivocal characters of the only compounds that ought be considered as combustible, being determined, I resume my oposition, and I say, that we cannot find any such combustible ody from which any portion of air can be obtained by any means.

The only bodies really inflammable that we know in the vegeta- e and animal kingdoms, are *oils*, *resins*, *fat*, *ardent spirits*, and *bers*; and when vegetables and animals are half decomposed by e action of fire, without the concurrence of air, by distillation in ose vessels, that is to say, without combustion, the only inflamma- e matters that are obtained, are empyreumatic oils and charcoal.

In the *mineral* kingdom, which comprehends none but unorga- zed compounds, we do not know any inflammable substances but *tumens*, or rather their *oils*, *sulphur*, and *metals*.

But I say, to whatever analytic operations all these combustible odies be subjected, no air is ever obtained. This fact is well nown to chemists who are daily employing these bodies in their perations, and I have myself verified this fact upon most combus- ble substances. I therefore think myself entitled to conclude that l the known chemical facts concur in proving that the principle of mbustibility is not a compound resulting from the mixture of air d fire.

But since I am engaged in this discussion, and as it seems expe- ent to clear up the theory of phlogiston, which seems so obscure to any persons, notwithstanding what has been said on this subject the most profound chemists who have written, I will add a few onsiderations to endeavour to throw more light upon it.

When I mention my reasons for believing that phlogiston is not e result of fire and air, I am far from wishing to have it under- ood, that these two elements cannot unite and form together par- cular compounds. Such an assertion would be an evident contra- iction to what I have said. I have frequently maintained, and I ere repeat it, that all the parts of matter, whatever difference there ay be amongst them, are essentially capable of combining toge- her, that they even all tend to this union, ; and that it is constant- effected when it is not resisted by any particular obstacle: and it llows from thence, that air, and fire or light, being two material ubstances, may and ought to unite and combine together whenever hey meet in circumstances favourable to this union; and as Na- ure has, undoubtedly, made all the possible combinations, there ught to exist some compound of air and fire.

What I have said of combustible bodies, shews sufficiently, that f such a compound exists, we ought not to look for it among those ombustible bodies which I have mentioned, although almost all hat exist in nature are comprehended among them; but one kind s known which seems to be, or to contain, a compound of air and re, I mean to speak of *Gas*, or the *inflammable Gases*. But as this kind

kind of combustible bodies has its aggregation and several of the properties of air, we can scarcely avoid considering these gases but as compounds into which air and fire enter as constituent parts.

The nature of these gases, the examination of which is but lately begun, is not yet well known. Their inflammability is but just ascertained. We therefore cannot decide with certainty concerning their constituent parts. It is not even demonstrated, that air is one of their principles. But what is very certain, is, that they donot differ from all the other combustible compounds, in what concerns their combustibility, and that in particular they are subject to the general rule, viz. that none of these bodies can lose their inflammable principle by combustion, but by the action and intervention of pure and disengaged air. We know also that inflammable gases may transmit without combustion, their inflammable principle to other bodies, and particularly to the earths of metals. I have been a witness of the various experiments by which M. *Montigni* has ascertained this important effect; and we cannot doubt, that what remains of these gases thus decomposed by this operation, which is also an elastic fluid, is rendered as incombustible, as the residuums of all the other inflammable bodies which have lost their phlogiston by a similar translation. But, these facts, far from proving that these compounds of air and fire can enter, without being decomposed, into the composition of combustible bodies, and become their principle of inflammability, or the true phlogiston of nature, do, on the contrary, shew that these gases are nothing but mixts that may be decomposed, like all others, which owe their inflammability to the pure and simple matter of fire; and lastly, that as this same matter may be separated in its state of simplicity, without carrying off with it any portion of elastic fluid, to enter into the mixture of new compounds, there is truly but this pure matter of fire alone that can become the principle of inflammability, by being fixed in any compounds: in a word, it is the sole and true phlogiston and becomes so merely by being fixed.

Every thing then concurs to prove that the matter of fire, or rather of light, needs no intermediate substance to render it capable of combining with other bodies that are properly disposed to join and unite, as with air, water, earth, and in a word, with all kinds of matter; that particularly none of its properties shew, that it has occasion for air as an intermediate substance, but that on the contrary air is it's sole and necessary precipitant, in all those occasions where it ceases to be phlogiston, and becomes pure and disengaged matter of fire. And, I think, I may conclude from all these considerations, that as the matter of light is a one and identic substance, and does not cease to be so by being fixed and becoming phlogiston; phlogiston is also one and identic, as I have advanced; that phlogiston is as simple as the matter of light is, since it is only this same

matter

ter considered in its state of fixation and combination: lastly, the true phlogiston of nature is not a variable being, a *compound, product of an allay*, the *result of a combination of two elements, air and fixed in bodies.*

t would certainly be very interesting to know how, in what umstances, and with what phenomena, the matter of light or of does combine with other kinds of matter, to form the several po inds of which we know by experience and analysis that it constituent part. But by what means shall we rise to this sub- degree of knowledge? The combination of the first principles odies is inaccessible to our senses; we have not any idea of the re, of the mass, of the hardness, nor of any of the other essential ities of their parts. The primary integrant molecules of air, er, earth, and even the most compounded bodies, are as unknown s as those of light; we can perceive the results of their unions, of their separations, but the mechanism of these wonderful rations is one of those mysteries of nature, which will probably for ever hid from us. I will therefore avoid giving conjectures n a subject which I know is above my reach, and I will confine elf to relate the small number of facts that are known, which e some relation to this matter.

everal persons think that those kinds of phosphorus which ap- luminous in the dark, after having been exposed to the sun or he light, produce their effect by imbibing light, and by retain- it during some time. Although this opinion be not proved, must agree that it seems to be very probable: and if it was de- strated, it would prove, that light could adhere at least in a ain degree to bodies of different kinds.

f we expose to the focus of a burning glass, martial earths suf- ently calcined not to be attracted by magnets, upon a support ch cannot communicate to it any inflammable principle, they not indeed reduced thereby to iron, but they are rendered ca- le of being attracted by magnets. At least in a great many of se calxes differently prepared, on which I have made this expe- ent, I have not found any of them which could not be rendered able of being attracted by this method. But we know that the h of iron cannot acquire this property but when at the same e it approaches to the state of iron and resumes its phlogiston; as it can receive this phlogiston only from the light, or rather as light becomes the phlogiston thus received, this seems to prove t a part of the light of the focus that thus falls upon the mar- earth fixes and combines with this earth. This effect would be bably much more sensible, if these experiments were made in e vessels of glass, as is indicated by the experiment of the re- tion of calxes of mercury without addition.

It is at present proved, that the calx of mercury called *precipitate per se*, that *red precipitate*, that *turbeth mineral*, and even all the true calxes of mercury, may be revived into fluid quicksilver, without any addition, by the application of a proper degree of heat. As this reduction as well as that of all the other metallic calxes can be effected only in proportion as these earths resume the same quantity of the principle of inflammability which they had lost during their reduction into the state of calx, it follows that those of mercury are reduced into fluid quicksilver in the experiments abovementioned, merely because the matter of light which can pass through vessels, especially when red-hot, again re-combines in a sufficient quantity and intimately enough with the calx of mercury, to become its phlogiston, and thereby to re-establish it in its metallic state. But a circumstance to which it is essential to attend, is, that these reductions of mercury, without the concurrence of any other igneous principle than the matter of light, do not succeed but in proportion as there is no communication with air, as I have explained at the article *dephlogisticated air*, for if the same degree of heat be applied in vessels that are not perfectly close, then the revival does not happen, but the calxes retain their calciform state, are sublimed and even may be fused into a vitreous matter, as is said in the notes to the English Edition of the Dictionary of Chemistry,* and according to the experiment which M. *Beaume* affirms to have made. But is not this one of the facts which prove not only that phlogiston is not a compound of air and fire, but that on the contrary, if any substance is capable of preventing the matter of fire from uniting in compounds as phlogiston, air has certainly this property more than any other substance.

It appears from the facts that I have explained, that we begin to know some artificial operations, in which disengaged fire or pure matter of light is fixed in certain bodies, and becomes their phlogiston. Perhaps, when we observe more accurately and more attentively what happens in many other operations, we may discover more instances in which the same effect is rendered evident to our senses. But all these particular effects are nothing in comparison of those which nature continually produces in the great. The whole surface of the earth is covered with an immense multitude of vegetables which spring daily and are renewed; and these vegetables, from which animals draw their sole nourishment and the substance of their bodies, are filled with combustible principles. Whence proceeds the immense quantity of oil which they contain, and which may be obtained from them by decomposition? It is not the earth which can furnish it; for the earths the most favourable to

* This observation was taken from a note in Dr. *Lewis's* edition of *Newman's Chemistry*, where it is said, that the calx of mercury, when exposed to the focus of a burning glass, without addition, is vitrified. *Vol. I. p.* 134. *2nd edition.*

vegetation, contain but very little of it, in comparison of the
nts which grow in it; it is further very easy to shew that the small
ntity of oily matter contained in the earth is extraneous to it,
owes its origin to decomposed vegetables and animals. This
of vegetables, which becomes that of animals, and to which
y thing combustible seems to owe its origin, is then essentially
product of vegetation, and the entire vegetable kingdom is the
t shop in which nature makes the first combinations of the mat-
of fire, probably by means of their organic vital action, and by
echanism entirely unknown to us. But what we begin at least
know sufficiently well, are the facts which prove the great in-
nce of the pure matter of light in vegetation.

l the world knows that plants, even in the best ground, exposed
ir and to the degrees of heat that are most favourable to their
wth, do nevertheless languish, are discoloured, become long,
, and feeble, do either bear fruit and flower imperfectly, or
at all, when they are not in immediate contact with the light of
sun, or at least with full day-light.

t has been constantly observed, that those plants which are en-
ed in a place into which light does only come in at one side,
ine themselves towards that side where the light enters, even if
e towards the north.

Ve know that the middle part of certain plants, as cabbage and
ices, of which the inner leaves are gathered together and de-
led from the light by the external leaves, remains white and
ery, while the external part of these plants is of a full green
much less watery. Gardeners know very well that the only
ns of giving to certain esculent plants that waterynesss, which
ders them tender, and that whiteness which is esteemed, is to de-
l them from light, which they do by tying their leaves together,
y covering them with earth, straw, &c.

Lastly, *M. Meese*, has given us a very interesting series of ex-
ments in the Journal of the *Abbé Rosier*. These experiments
v in a more striking manner the influence which the contact of
e light has upon all plants, and the necessity of this influence to
etation. And as we cannot doubt but that those watery, colourless
nts, which have not received much light during their growth,
ld less oil in their analysis than those plants which have enjoyed
benefit of the full influence of light, it is a sufficient proof that
proper substance of light is fixed in all plants, and enters ma-
ially into the composition of the only one of their principles that
ombustible, that is to say, of their oily part.

I am well inclined to believe, with most chemists, that the light
omes the cause of all colours; and the opinion which Mr. *Opoix*
explained in two good memoirs, inserted in the collection of
*Abb. Rosier*, appears to me to be very probable. This able

 chemist

chemist has collected and compared together in a very satisfactory manner, a great number of phenomena, the total of which serves well to prove that not only light is the material principle of all colours, but also that when it becomes by being fixed, the phlogiston of bodies, it produces each kind of colour, according to the manner in which it is combined.

I shall not enter here into longer details upon these subjects. But I believe that what I have said upon them, added to the observations in Natural History, will be sufficient to convince those who will give themselves the trouble of reflecting upon these facts, that phlogiston is nothing but the pure matter of light fixed immediately in bodies, without the concurrence of any intermediate substance, and especially without the concurrence of air; that it is primarily fixed in vegetables, and that this fixation is effected by the vital organic action of these beings, whence results the composition of all oily substances; that the matter of light being once fixed and become phlogiston in the oils of vegetables, passes afterwards easily from one combination to another, and enters into many different compounds without becoming disengaged fire; so that these oils are the first origin of all the phlogistic and combustible compounds that we know. And if these ideas, which at present are only probable, were well demonstrated, it would follow that without vegetation, there would be neither oils, resins, animals, fat, coal, bitumens, sulphur, or metals, on the surface and within the earth. It is also even probable that no saline matter would exist, and that our globe would be merely a mass of simple earth, covered part or wholly with very pure water, and surrounded with air which would be no less simple and pure.

*Addition to the article* PHOSPHORUS *of the former edition.*

THE origin of phosphoric salt is not yet well known. Mr. *Margraaf* says, that he has obtained phosphorus by distilling wheat, mustard seed, and some other vegetable matters, and seems to be of opinion, that the phosphoric acid or salt passes from vegetables to animals. But although the greatest confidence is due to what is affirmed by this illustrious chemist, yet this extraction of phosphorus from vegetable matters has not yet been confirmed, although we have reason to believe that it has been attempted by several chemists. Some chemists are even of opinion that the phosphoric acid is produced in animals, and they consider it as the *animal acid.* It is however certain, that it may be obtained with great ease and abundance from animal matters.

Till lately, it was procured only from urine, and even from human urine alone, and not from that of other animals. But as it is not possible that the urine of all animals can have been examined, we cannot determine whether the human urine is the only one that contains it. We are indebted to Mr. *Scheele*, whom I have quoted

at

he article *Bones of Animals*, for an important discovery, and ich appears very proper to throw light upon the origin of the sa- matter, to which the name of *phosphoric acid* has been given. is discovery is, that this acid is contained copiously in the earth he bones of animals. We shall find at that article the processes Mr. *Scheele*, and a summary account of those experiments which e been made since, upon that matter: and I shall only add e, that the saline phosphoric matter obtained from bones by ns of the vitriolic acid, although proper for the making of sphorus, appears nevertheless to differ in some respects from acid that remains after the combustion of phosphorus, and that it is not entirely similar to the crystalline substance which *Duke of Chaulnes* obtained by distillation and by fusion in a crucible n the phosphoric salt of urine with basis of volatile alkali. These erences are not yet well ascertained; and it appears to me from at I have hitherto been able to learn, and from the comparison ich I have made on the vitreous matter obtained from bones, h that of the fusible salt of urine, which the *Duke of Chaulnes* s so obliging as to give me a specimen of, that this latter retains acidity, a deliquescence; and a solubility in water, which the mer does not possess. I am also informed by Mr. *Rouelle*, that saline phosphoric matter of bones, yields less phosphorus than matter of phosphorus itself, or than the fusible ammoniacal of urine does. There is room to believe that these differences ceed from some portion of the vitriolic acid remaining united th some earthy or selenitic matter, which combines along with saline glass during its vitrification, and diminishes in some de- ee its saline properties. *See* the articles BONES and URINE.

## *Addition to the Article* PHOSPHORIC STONES.

BESIDES the phosphorical effects of certain stony and earthy matters which I have already mentioned, there are others hich perhaps may have some relation to these. I shall only give a mmary account of them, as the experiments on this subject have t yet been sufficiently varied to enable us to form a just idea of e causes on which these effects depend.

It is known that *diamonds*, without any previous calcination, ing carried into the dark, after they have been exposed to the n or to strong day-light, appear luminous. They are, perhaps, t the only stones which have this property.

*Rock-crystal*, *quartz*, *agates*, *siliceous stones*, and probably all the ard stones which are of the kind called *vitrifiable*, being struck r rubbed strongly one against another, in the dark, throw out uch light. All kinds of *glass* and *porcelain* have the same effect. This light does not consist in sparks that are darted outwardly like hose produced by the collision of these substances with steel, but

in a flash of light which illuminates suddenly all the internal part of these bodies, if it is produced by percussion, and which is permanent, if it is produced by the continued friction of a mill-stone in motion. Is this an effect of electricity? This cannot be decided but by other experiments. I am however inclined to believe that this light is neither the electric matter, nor the phlogiston disengaged from these bodies, but only that which is universally diffused, which is not visible in the dark, because it is not darted towards our eyes, but which becomes very sensible to us, when it is thus darted by the vibratory motion excited by percussion in the infinitely small parts of these hard transparent bodies, and which thus do only become luminous, because they begin to be heated. *See* what I have said on this subject concerning the nature and effects of heat at the article FIRE. In the great cold of 16 degrees in January 1776, I struck strongly against each other two pieces of ice which had been frozen in the open air. But although this ice was very hard, and had been exposed during a long time to the intense cold, I did not perceive any light. I nevertheless think it probable that it would be luminous, if it could acquire a greater degree of hardness by as much more intense cold, such as that which is necessary to the congelation of mercury.

Several *spars*, and particularly the *heavy spar* called by Mineralogists, *vitreous spar*, *sparry fluor*, *false emerald*, that from which Mr. *Scheele* has obtained the *acid of spar*, when broke into small pieces, and spread upon a very hot plate of iron, appear to be very luminous in the dark, and each parcel of these spars resembles a fine star, or a piece of luminous phosphorus.

This effect is however not peculiar to spars. Mr. *Lavoisier* has lately communicated to the Academy the observation which he has made upon a kind of chalk that possessed this property in a very sensible manner. Since that, it has been found not only by Mr. *Lavoisier*, but also by others, that a great number of calcareous earths had the same property, and even that none have been tried without producing this effect. Hence it is probably common to all earths of this kind, but probably some of them give a more lasting and intense light than others. For this light soon becomes extinct, although the plate of iron on which it is placed be kept hot. I have made some experiments on this subject, of which the following are the results.

The *calcareous earth* which contains all its animal matter, which has undergone no alteration, nor destruction by a long continuance in the earth, as it is in fresh oyster-shells, merely washed, dried and pounded, becomes luminous, when put upon a plate of hot iron. But its light appeared to me fainter than what was produced by the chalk of Bourgival.

The

The *magnesia of Epsom salt* uncalcined yielded a pretty good and durable light. The same earth when calcined produced a light that was weak and not durable.

The *earth of the bones of animals*, uncalcined, precipitated from its solution in the nitrous acid, well washed and well dried, gave a finer and more durable light than that of the uncalcined magnesia.

The *quartzose pebbles* of the Loire, uncalcined, being pounded, gave a weak and not durable light.

The *earth of alum*, precipitated by a fixed alkali, well washed and well dried, uncalcined, exhibited a very fine and very durable light.

Lastly, what is singular, *vitriolated tartar*, powdered and put on a heated plate of iron, gave a phosphoric light as intense and durable as that produced by the chalk.

These experiments were made in cold dry weather, such as is very favourable to electricity, on the 18th and 19th of February, 1777, during the night. I repeated them on the 20th of that month, when the air was become mild and moist, but did not perceive any difference in the results.

They were also made upon an iron shovel, which I had made red-hot and left to cool till it was no longer visible in the dark, after which I placed on it the matters subjected to experiment. I substituted a piece of porcelain in place of the iron, and the effects were the same.

I have since made some trials of the same kind on several other matters of a very different nature, in hopes that by multiplying them, the cause of this phenomenon might be discovered. But probably a much greater number is required for this purpose. I have only seen that *quick-lime slaked in the air*, and the kind of *talk* that is known under the improper name of *chalk of* Briançon gave a light nearly equal to that of ordinary chalk; that *gypsum* or *plaster* became less luminous than chalk; that *mild fixed alkali* was infinitely little luminous; that *black flints*, calcined to whiteness, were much more so; that *diaphoretic antimony*, *putty* or *calx of tin*, washed *colcothar*, *emery* and several *ferruginous sands*, that were shining, magnetic and not sulphureous, being tried upon a heated plate of iron, gave no light; that *luna cornea* and *white arsenic* placed upon a dish of baked earth, heated to the proper degree, gave little, if any, light; and lastly, that *corrosive sublimate* placed upon the same dish, exhibited one of the most beautiful phosphoric spectacles that can be seen. I believe nevertheless, that the dish was hotter in this last experiment than in those made upon luna-cornea and arsenic: and in general, I ought to give notice, that the intensity of the light was considerably affected by the heat of the supporting plate; and as it is not possible that this heat could have been precisely the same, in all these experiments, whoever shall repeat them, will probably

find some difference in the results, although I do not believe that these differences will be considerable, as I took all the care I could to keep this degree of heat nearly the same.

These facts are not yet sufficient in number to enable us to draw any general conclusion from them. It will be necessary, as I have already said, to multiply these proofs much more, and they certainly well deserve to be prosecuted.

## *Addition to the Article* PLATINA.

SINCE our experiments on platina, the *Count de Buffon*, the *Count de Milly*, M. *de Morveau*, the *Baron de Sickingen*, and others have made new interesting researches on this singular metallic substance. Excepting those of the *Baron de Sickingen*, which are not yet published, the others are related at length in the first volume of the supplement to Mr. *Buffon*'s Natural History. This illustrious naturalist gives an account of the experiments which he himself made, and those which he made along with Mr. *Tillet*, of the Academy of Sciences, to determine the specific gravity of platina. These experiments consisted in comparing it with pure gold, by weighing an equal bulk of each of these matters in particles or grains, nearly of the same size and form, and the bulk of which was determined by the space which they occupied in a quill. Considerable differences were observed in weighing different parcels. But when the average of these trials was taken Mr. *Buffon* estimates, that the specific gravity of platina is less than that of gold by one twelfth part.

Having carefully examined the magnetism, both of the ferruginous sand naturally intermixed with platina, and of the grains of the platina itself, and having found that almost all these matters were more or less sensible to the action of the magnet, Mr. *de Buffon* concludes from these observations and from several experiments of of the Count de *Milly* and of M. de *Morveau*, which I shall presently mention, that this metallic matter is not a particular metal like gold, or silver, but is an allay made by nature, of gold and iron in a particular state, and combined together more intimately than can be done by art. I do only relate this opinion, which is also that of M. de *Milly*, without entering into an examination at this time of its probability, that we may not interrupt the recital of the new experiments that have been made on platina.

M. de *Milly* having digested in spirit of nitre some grains of platina which were no longer attracted by the magnet, and not having remarked any effervescence, or other sensible mark of solution, he then mixed this acid with some of the alkaline liquor that was saturated with the colouring matter of Prussian blue, and did nevertheless produce a blue; from thence M. de *Milly* concluded that this

platina

ina, although not capable of being attracted by a magnet, did ever contain some iron which the nitrous acid had taken from But M. *Morveau* repeated this experiment, and did not thereby duce any Prussian blue.

This excellent chemist pushed very far his trials upon the fusion cupellation of platina. He was able to melt it in a wind-fur-e, without any metallic addition, and by means of a reducing of his invention, composed of eight parts of pulverised glass, one part of calcined borax, and of half a part of powdered char-l. I have myself been a witness of the efficacy of this flux in ons of iron-ore, which were effected by Mr. *Morveau* in my nace and in my laboratory, along with the *Duke of Rochefoucault*, . de *Trudaine*, Mr. *Lavoisier*, and some other distinguished che-ts. We obtained a button of iron perfectly well fused, well re-ed, and on which was marked distinctly the crystallisation which . *Morveau* never fails obtaining in the essays of ores of iron, the cess for which he has considerably improved.

With regard to the cupellation of platina by means of lead, we d in Mr. *Buffon*'s work, which I have quoted, the detail of the e experiments which Mr. *Morveau* has made to push this opera-n as far as it can be carried in the furnaces of laboratories. He ployed for this purpose an air-furnace, of which I have given escription in the memoirs of the Academy of Sciences. After had cupelled a mixture consisting of one gros of platina and two s of lead, in four successive operations, during which this fur-ce had been carefully supplied with fuel so as to produce its atest heat, which lasted in all eleven or twelve hours, he at gth obtained a button of platina, well collected, not adhering the cupel, of a continued uniform colour, more nearly resembling colour of tin than any other metal, only a little rough, weigh-g an exact gros, and not sensible to the action of the magnet.

I have since that time made some other experiments of the cu-llation of platina, in the the focus of the great burning glass of . de *Trudaine*. I will not give the detail of these experiments cause they are not yet finished, but shall only say, that having posed at five different times, a mixture of equal parts of lead and tina, to the focus of this powerful instrument, I obtained a mass newhat granulated, like matted silver, which did not smoke any ore in the focus, as white as the purest silver, and received no eration in its colour by exposure to air. I was not able to weigh s button, because it was fixed in a mass of glass which proceeded m the fusion of the substance on which it was placed. This tina, the whitest that I have ever seen, and which I have reason believe to be the purest, could easily be filed, and became po-ed under the hammer. I return to Mr. *Morveau*'s experiment.

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Upon a further examination of the button which proceeded from this cupellation, its specific gravity was found to be that of water as fourteen and two-fifths to one, while that of pure gold, when compared to it was as nineteen and one thirty-fourth. It is remarkable that this button, which was not malleable, having been broken, the fracture shewed several cavities, some of which about a line in diameter, had the whiteness and brilliancy of silver; a circumstance which sufficiently shews that its specific gravity as above-mentioned was not just.

A part of this same button, which did not appear sensible to the action of the magnet, having been reduced in an agate-mortar into a very fine powder, these particles gave still some signs of magnetism.

"Lastly, Messrs. *Buffon* and *Morveau* observed together that by "bruising this cupelled platina, its parts resumed precisely the "same roundish flattened forms as they had before their fusion. "According to Mr. *Buffon*, this operation seems to prove that "although the fire was strong enough in the experiments of M. "de *Morveau*, not only to burn and vitrify, but also to expel a "part of the iron with the other vitrescible matters which it con-"tains, the fusion is nevertheless not so compleat as that of the "perfect metals, since, when it is bruised, the grains resume the "same figure which they had before fusion."

This remark appears so much the more just, as upon a thorough examination of the properties of the several parcels of platina which I had melted by different processes, none of them seemed to be possessed of such a malleability as was perfect, or proportionable and correspondent to its other metallic properties. This matter is in fact so refractory, that perhaps it never did enter into a compleat fusion, and that what has been considered as such, has been really nothing but a more or less intimate agglutination of its parts. This happens, I believe, in an apparent fusion of platina, which may be effected by a moderate heat, according to M. *de Fisle*'s experiment, which I have verified, and which consists in exposing to a good ordinary fire of a furnace or forge, some platina precipitated by sal ammoniac from its solution in aqua regia. This precipitate seems to melt easily enough into a metallic mass smooth and dense, but it perfectly wants malleability while it is exposed to a moderate heat, and resumes an imperfect degree of it only in proportion as the heat is rendered more intense. The parts of platina being infinitely divided in the above-mentioned precipitate, it is not astonishing that heat should penetrate such small particles much more effectually than ordinary grains of platina, which are enormous masses in comparison, and as their softening is in proportion, they ought to suffer the ordinary effect of their agglutination, in proportion to their points of contact; but as these points are infinitely

more

re numerous than those of much larger molecules can be, the d masses which result from the fusion have the appearance of a tal that is dense, melted, and hardened by cooling, but in reality y are only the result of a simple agglutination between an infinite nber of particles infinitely small, and not that of a perfect fusion, e the fusion of other metals. At least this account of the matter ms to me to be the most probable.

I do not know if all the experiments hitherto made on platina sufficient to enable us to decide concerning the nature of this tallic matter. I have already said that I was inclined to con- er it as a particular metal, as simple and perfect in its kind, as other metals are in theirs. The only objection that has been de, or that may be made against this opinion, is, that platina, hough it possesses the essential properties of metals, and even of perfect metals, has not however either the fusibility, or all the tility of the simple metals.

As to the ductility, it depends on a good fusion, not only of this tal but also of the others; and it depends so visibly upon this se in this instance, that the ductility of platina is found to be in portion to the degrees of heat, and of the softening or agglutiion that are given to it. It is a truth of which I am convinced a great number of experiments, and I doubt not but the other emists who have worked upon this matter have made the same servation. The want of fusibility remains: but besides that this not an absolute and limited quantity; that it is only relative to e different nature of each body; it is certain that, without going t of the class of metals to bring instances, the difference between e fusibility of lead and the purest forged iron, is enormous; and s difference, however great it is, does not hinder, and ought not hinder iron from being considered as a simple metal with as good son as lead. Why then should not a gradation be admitted for metallic bodies? Why should platina, whose fusibility is not so different from that of iron, as the fusibility of iron differs from at of lead, be excluded by this sole difference from the rank of nple metals; and how shall we determine the limits of fusibility, rather of the difficulty of being fused, beyond which a metallic atter cannot be reputed any thing but an allay, and not a simple etal? Certainly we cannot give any good answer to these quesons, and it follows from thence that all which we know of the operties of platina do not prove that it is not a simple metal, like e others. Let us see then what may be the motives which have ade it considered as an allay of gold and iron. This mineral has, is said, properties which partake of those of gold, and of those iron. Its colour, density, hardness, and magnetism may be itated by allays of these two metals in certain proportions. Lastly, whatever degree of purity platina may be brought, it always

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gives some marks of magnetism, which prove that it is not entirely exempt from the allay of iron.

I acknowledge that as compounds partake most frequently, to a certain degree, of the properties of their component parts, and that in fact some properties are observed in platina which resemble those of gold and of iron, there are sufficient grounds for a suspicion that it may be only an allay of these two metals. But it must be also acknowledged that this can be nothing more than a mere suspicion, while there are no other proofs to support it than an imperfect resemblance, like that which we have mentioned. But it is certain that the proofs of those who embrace this opinion extend no farther; for to whatever trials platina has hitherto been subjected, the gold has not been separated by any of the methods by which this metal may be separated from its allay with other metals, particularly with iron; and also, in whatever manner and in whatever proportions gold has been combined with iron, no allay has been ever made which could be considered as an imperfect platina.

To this it is answered, that the iron which is thus combined with gold in the platina is not in its ordinary state; that this metal is found daily in very different forms and states; and lastly, that it requires to be in a very peculiar state to enable it to form with gold true platina.

In the first place, I shall observe upon this subject that this supposition is repugnant to all the positive and ascertained facts in metallurgy, all which concur in proving, that no metal can be allayed in its compleat metallic state with another metal, unless this latter also be in its compleat metallic state: And if it be said, that we ought not to confine our reasonings to the routine of chemists, and that nature finds the means of making combinations which they are not acquainted with; we may acknowledge that such an allay as is here mentioned is not shewn to be impossible in this sense, but nevertheless, in order to make me believe that it really does exist, it will be necessary to shew that platina has been made by combining gold with iron in that state which is supposed to be necessary for imitating the process of nature. For it is very evident, that if we were permitted to alledge mere possibilities, to support which we have occasion for as many suppositions as there are difficulties that occur, we might prove whatever we pleased; for instance, that gold is nothing but an allay of silver and copper, which copper is in a certain state, and combined by means very different from those employed in ordinary chemical processes.

As to the small portions of iron which remain obstinately united to platina, notwithstanding the effects of the greatest heat, and of the strongest cupellation; this phenomenon is not peculiar to these metallic matters. It is even very general, since it is constantly observed in all the analyses of parting, and in the other operations of

chemiſtry. Whenever one ſubſtance is ſeparated from another, laſt portions of that whoſe quantity is the ſmalleſt, are ſo much more difficult to ſeparate as leſs of it remains, ſo that at laſt we d that a perfect ſeparation cannot be obtained. This is the rea- why it is ſo difficult to attain a purification that is ſo rigoroufly fect: Thus, for inſtance, it is almoſt impoſſible to bring gold the mathematical degree of fineneſs of 24 karats. Although refore, the allay of iron were no more eſſential to platina, than t of ſilver or of copper is to gold, it would not be any matter of prize, if we could not ſeparate perfectly the laſt infinitely mi- te portions of this metal, which are allayed with it in its native te. Nevertheleſs I can affirm that the platina of a ſhining white our like ſilver, which I have obtained by cupellation in the focus a large burning glaſs, did not ſhew any ſigns of magnetiſm by e moſt accurate trials that I was able to make. Not only this mp of platina appeared to be quite inſenſible to the action of a ry ſtrong artificial magnet, but alſo when I made it float freely on the water by means of a piece of cork, I could not obſerve at the magnet produced the leaſt motion in it, not even when I ached it with a magnet that was capable of ſuſtaining ſix ounces. endeavoured to repeat the experiment of Mr. *Morveau* upon this me platina, that is, to reduce it into very ſmall parcels. For that rpoſe, I bruiſed a ſmall piece of it between two flat ſurfaces of ck cryſtal, but I found that this little piece, which weighed about h of a grain, and which could only be flattened and polished by is means, was not attracted in any degree by the magnet, even hen it was made to float upon water by means of a bit of wax.

Theſe experiments ſeem to me to ſhew, that if it is not poſſible o ſeparate the laſt atoms of iron allayed with platina; we may at aſt carry this ſeparation ſo far, that nothing remains of it but a uantity infinitely ſmall and not to be eſtimated. But it is a re- mark worth making, with which I ſhall cloſe, that if platina be in act an allay of gold and iron, it ought to reſume the properties of old in proportion as it ſhould be deprived of its iron, whereas, on he contrary, it thereby becomes more white, and the properties y which it differs from gold, become more diſtinct.

SOAPS (ACID.) Alkalies are not the only ſaline ſubſtances hat are capable of combining with oils, ſo as to form compounds apable of ſolution in water and in ſpirit of wine. Perhaps indeed, igoroufly ſpeaking, every ſaline matter has ſome action upon oils, and communicates ſome degree of a ſaponaceous quality propor- tionable to this action. Nevertheleſs, the ſalts which are not evi- dently cauſtic, have but an infinitely ſmall degree of action upon oils, and it would be an infinite labour to ſubject to a compleat che- mical examination all the ſalino-oily combinations that can be made. But as acids have in general a very ſtrong cauſticity, and

particularly

particularly a decided action upon oils, it was important to make at least the principal compounds that could result from these two sorts of substances, and to investigate the most essential properties of these new compounds, which had been absolutely neglected by chemists till lately. The academy of Dijon, who generally make choice of their prizes with much judgment, proposed the discussion of this matter as a proper subject. As this prize has been deferred five years successively, we cannot doubt but several chemists have during that time been making experiments on this subject. I know particularly one very good memoir on acid soaps that was sent by Mr. *Cornette*, but it arrived after the expiration of the limited time, and therefore could not enter into the competition for the prize. The author intends to publish it soon. About the same time Mr. *Achard*, of the academy of Berlin, published an extensive work upon *soaps whose saline basis is vitriolic acid*; and as this memoir is printed in Mr. *Buchoz*'s journal called *Nature considered under different Aspects*, I shall mention the principal experiments made by Mr. *Achard*, without pretending to decide concerning the debates about the analogous experiments and discoveries, which other chemists and particularly Mr. *Cornette*, have made on the same matters.

"The process, which succeeded with Mr. *Achard* in making acid "soaps by combining vitriolic acid with oils, both concrete and "fluid, drawn from vegetables by expression, or by boiling, con-"sists in putting two ounces of concentrated white vitriolic acid "in a glass mortar, and in adding to this by degrees, and during a "constant trituration, three ounces of the oil of which the soap is "intended to be made, which had been previously heated, even "almost to ebullition. Mr. *Achard* obtained by this process, black "masses which when cooled had the consistence of turpentine.

"According to the author's remark, these compounds are al-"ready true soaps: But in order to bring them to a more perfect "and more neutral combination, it is necessary to dissolve them in "about six ounces of distilled boiling water. This water takes up "the superabundant acid that may be (and which probably is "always) in the soap; and the saponaceous parts join together "when the water cools into a brown mass of the consistence of "wax, which sometimes occupies the bottom of the vessel, and "sometimes swims upon the surface of the fluid, according to the "weight of the oil employed. If the soap still should contain too "much acid, which may be easily known by the taste, it is neces-"sary to dissolve it once more in distilled boiling water, and to "repeat this operation till it has entirely lost its acid taste. In "this manner a soap is obtained whose component parts are *in a* "*reciprocal state of perfect saturation*.

"Mr. *Achard* remarks further, that concentrated vitriolic acid "acts very strongly upon oils, and gives notice, that it is necessary

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"to take care that the oil be not added too suddenly, and in too "great quantity, because in this case the acid becomes too strong, "decomposes the oil, and changes it to a substance resembling "charcoal. This decomposition is manifested by the smell of vo-"latile sulphureous acid which exhales.

"When these soaps are carefully made, (says Mr. *Achard*) they "become hard by age; but if they contain a superabundant acid, "they become soft in the air, the moisture of which they attract."

This chemist has composed vitriolic acid soaps with different oils, such as those of sweet almonds and of olives, butter of cacao, wax, spermaceti, and the expressed oil of eggs. He has made soaps with essential oils; but as the vitriolic acid acts much more forcibly and quickly upon essential oils than upon the other mild oils, and as it is always necessary in these combinations to avoid the too quick action of the acid; the process for the composition of acid vitriolic soaps with bases of essential oil requires some particular attentions and management, which Mr. *Achard* points out in the following manner.

"In the following process (says he) I succeeded in making "soaps with vitriolic acid and any essential oil. I poured three "ounces of white oil of vitriol in a glass-mortar placed in cold wa-"ter. To this I added slowly, drop by drop, four ounces of the "essential oil that was intended to enter into the composition of "the soap. I triturated continually this mixture, and when it "began to be hot, I added to it no more oil, before it was entirely "cold. I continued this method till all the oil was mixed with the "acid. That being done, I poured about a pound of water upon "a pound of this mixture, and I heated it slowly, till it acquired "a heat nearly equal to that of boiling water. I then removed "the mixture from the fire. By cooling, the saponaceous parts "united into a brown mass, more or less solid, according to the "nature of the oil employed."

The author gives notice that too great a heat occasions a decomposition of the oil by the vitriolic acid, and converts it into a semirefinous kind of coal, which is easily known, as also in the mixtures of the same acid with the oils that are not volatile, by the smell of volatile sulphureous acid, which never fails to be sensible when it acts so strongly as to decompose the oil. To prevent this decomposition the above described cautions to keep the mixture cold are intended; and it is even necessary that the water added to cleanse the soap from any superabundant acid, should not be made so hot as to boil.

Mr. *Achard* has made soaps of this kind with the essential oils of turpentine, fennel, and other oils, which though not strictly essential, are no less volatile, as the oil of amber, animal oil of Dippel, and oil of wax.

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We cannot doubt, as the author very well says, that all these combinations of vitriolic acid with different kinds of oils, are true saponaceous compounds, acid soaps well characterised, when the combination has been properly made: for he found from experiments, that each of these compounds were soluble either in water or in spirit of wine, and capable of being decomposed by fixed or volatile alkalies, by calcareous earths, and by several metallic matters, all which substances seize upon the acid of the soaps, form with it new compounds, and disengage the oil, in the same manner as acids separate the oil from alkaline soaps.

Besides these observations, which are common to all these soaps, Mr. *Achard* has made upon each of them a great many particular experiments, which exhibit many very curious and important phenomena, in this respect, that they extend our knowledge on the nature of the different kinds of oils. It would be too long to enter here into these details, which may be seen in the work itself. I shall content myself with relating the principal results, and shewing the most general consequences which I think may be drawn from them.

Not only alkaline, and several metallic matters decompose vitriolic acid soaps, but also most of the other acids, as the nitrous, the marine, the volatile sulphureous, and even vinegar, are capable of effecting this decomposition, which is a very remarkable phenomenon. Nevertheless the effect of the acid of vinegar is not the same upon all these soaps, for it is not able to decompose some of them. Tartar and salt of gooseberries decompose these soaps; but there is reason to believe, as Mr. *Achard* thinks, that it is by means of the fixed alkali which the saline matters contain, that they produce this effect.

Several neutral salts, with different bases, do also decompose these acid soaps; some of them by the greater affinity of the vitriolic acid with their bases; and most of them by means of a double affinity.

But a very remarkable circumstance is, that in whatever manner these soaps be decomposed, including even distillation without any intermediate substance, the oil which is separated is found to possess and to retain a stronger consistence than it had naturally. Most of the oils thus separated become concrete and as hard as wax, whereas the oil that is separated from alkaline soaps, as Mr. *Achard* remarks, is more fluid and attenuated than in its native state. This effect appears to me to shew that the decomposition of acid soaps is not complete, and that the oil having been once combined with vitriolic acid, retains always a portion which augments considerably its consistence. The case is quite different with alkaline soaps; the alkalies when they combine with oils, seem to deprive these of a part of the acid naturally united in their composition, and to which

tartar

ir natural consistence is owing; and when we separate these oils m the alkali, it does not restore to them all their acid, and accordingly the oils thus separated, become more fluid than they were ore they were combined.

Another general observatiou upon the decomposition of acid soaps alkalies, and which is no less important, is, that when we employ s method of decomposition, we must observe to add no more ali than the quantity necessary for the saturation of the acid, beise the overplus does not fail to combine with the separated oil, l to form with it an alkaline soap, even much more easily than the direct and ordinary combinations. Accordingly Mr. *Achard* narks, that the decomposition of the vitriolic acid soap of the estial oil of turpentine, affords an easy and quick method of making *rkey's soap*, which is so long and difficult by the ordinary proses. To make this soap, nothing more is required, than to add the solution of this acid soap, a greater quantity of alkali than is essary to saturate the acid, and then to make the mixture boil. this method, says the author, *Starkey's soap* may be made in a minutes. The reason of this effect is, that the fixed alkali ds in this operation the essential oil of turpentine, at the instant its separation from the vitriolic acid, in a much more perfectly vided state than can be effected by any other means.

We might probably avail ourselves of this same method, for the mposition of acid soaps, which in general are more difficult to made than the alkaline soaps, not only because there is danger decomposing and altering the oil, but also from the nature of e combination, and from the excess of acid that ought to be added order to make it well, at least according to the process of Mr. *hard:* for Mr. *Cornette* has assured me that he has been able to ke these soaps with much less acid.

I have tried to combine vitriolic acid with lintseed oil, by adding adually the acid to the oil, instead of adding at different times all quantities of the oil to the acid, as Mr. *Achard* does, and I ve observed that the combination is soon effected by this method. everthelefs the oil was much blackened and acquired a pitchy contence, had a considerable excess of acid, which partly separated deliquescence. Nevertheless this saponaceous compound apared to me to be imperfect, particularly because it was much less luble in water than in spirit of wine; which property seems to be mmon to all acid soaps, and even to alkaline soaps, but in a less gree.

I succeeded in making a soap with oil of olives and vitriolic acid, hich appeared to me to be perfect, in the following manner: I ssolved ordinary alkaline soap in vitriolic acid, taking care so to roportion the quantity of each, that there should be an excess of id in the mixture. At first, I tried to effect this combination by

means of vitriolic acid diluted with much water, in order to prevent the oil from being blackened and altered. But although there was evidently an excefs of acid, the oil of the foap feparated partly in the ftate of a very white and very limpid oil, very foluble in fpirit of wine, but infoluble in water; partly into a very concrete oily matter, of the confiftence of greafe, very foluble in fpirit of wine, but unfoluble in water, and confequently the dilute vitriolic acid had not been able to act with fufficient ftrength upon the oil of the foap to reduce it into a faponaceous compound.

The cafe was very different when I triturated fome alkaline foap, made of oil of olives, along with concentrated vitriolic acid. From this mixture a brown compound refulted, which contained a perfect foap. In order to purify the foap, I diffolved it in fpirit of wine, which feparated from it all the falt of Glauber and vitriolated tartar which were formed during the operation. I then added to it gradually and carefully, fome liquid fixed alkali, in order to faturate the excefs of acid; by which means more vitriolated tartar was precipitated. Laftly, I filtrated the liquor which then appeared tranfparent and yellow. When it was fhaken, permanent bubbles appeared exhibiting the fame irifes as the bubbles of ordinary alkaline foap. I evaporated the liquor with the heat of 35 or 40 degrees of *Reaumur*'s thermometer, and during the evaporation yellow tranfparent drops were formed upon its furface, which I took at firft for oil that feparated; but when cold, it became a concrete yellow fubftance of the confiftence of greafe or fuet, having the fat rancid tafte of ordinary foap; with fpirit of wine a very limpid folution, without any feparation taking place; and this latter folution being evaporated to dryneefs by a mild heat, was thickened into a foap of the fame nature as before its folution by water.

From thefe facts it appears that by the procefs which I followed, a perfect acid foap may be eafily formed with vitriolic acid and oil of olives. There is reafon to believe, that the oil is lefs altered by this method, than by a direct combination with concentrated vitriolic acid, although in the decompofition of ordinary foap by this acid, a flight fmell of volatile fulphureous acid is perceived. This acid foap is exhibited under the form of a fluid oil, when the fpirituous acidulous liquor in which it is at firft diffolved is evaporated from it, becaufe it liquefies at a very gentle heat, and becaufe the acid watery fpirit of wine can only keep in folution a determinate quantity of it. When there is a certain quantity of it thus collected upon the furface of this liquor, it may be eafily feparated by allowing it to become folid by cooling, and to pour off the liquor on which it fwims. When it is again rediffolved in water, and the folution is evaporated by a gentle heat, it thickens into a white acid foap, which feems to be poffeffed of all the qualities that could be expected in fuch a compound.

I do

y be able to compose all other kinds of
l. or by that of Messrs. *Achard* and
cess more simple, more easy,
uch more importance to be
aceous compounds seem to be
r remedy which may be very ef-
proceeding from obstructions and con-
e diseases of that kind, where ordinary
certain degree, and during a certain time,
effect. It appears to me very probable, that
ch happen too frequently, an acid soap substitut-
an alkaline soap which has ceased to act, might
effectual, and that the alternate use of these two reme-
perhaps produce better effects than could be expected
ther of them singly. At least many chemical operations
, that the successive application of two solvents of different and
opposite natures produces solutions which could not be effect-
r but imperfectly by either of them alone. I have published a
singular effect of this kind in the Journal des Sçavans, for
ember, 1776, on the solution of the stoney depositions of
e; and a great many other proofs may be seen in a letter filled
very interesting researches and experiments on the same subject
h Mr. *Morveau* has done me the honour to address to me, and
ch is printed in the same Journal for February, 1777. As the
s, although they are powerful and active solvents, have never-
es no causticity which can render them formidable to the most
ent physicians, they may be tried with great safety, which in
cine is no small advantage.

ut besides this use of acid soaps which may become of the
est importance, it is almost certain that they may become very
l in arts and manufactures. In many arts the utility of com-
soap is ballanced by inconveniences which, perhaps, the acid
may be without. Time and experience alone will shew what
t to be expected from them; for notwithstanding these first la-
s so well begun, this subject may be considered as being only
pened.

## *Addition to the Article* S U G A R.

Lthough a very small quantity only of oil be obtained by ana-
lysing sugar in a retort, we cannot doubt that this substance
ins a great deal of oil. This is proved from the phenomena
e spirituous fermentation of which sugar is the true matter,
rom the nature of the products of this fermentation which are
flammable, and from several of which, a very great quantity
l may be obtained, as Mr. *Rouelle* has very well observed;
but

but this acid is ſo combined with the peculiar acid of ſugar, that it cannot be ſeparated by the ordinary analyſis. It is the peculiar combination of this oil and of the earthy parts with the acid, which gives to the eſſential ſalt the ſweet and agreeable taſte, and the fermentable and nutritive qualities which it eminently poſſeſſes; and it is very probable, that by ſeparating from its acid a conſiderable portion of its oil and earth, it might be obtained under the form of a very ſtrong and powerful concrete acid. At leaſt, this ſeems to be the reſult of ſome intereſting reſearches and experiments which Mr. *Bergman* has publiſhed upon this matter.

This intelligent chemiſt, by applying to ſugar and to other ſaccharine matters, a large quantity of nitrous acid, obtained from thence a very white, pure, well cryſtallized concrete acid, whoſe acidity is of ſuperior force even to nitrous acid, at leaſt with regard to the affinities, to which Mr. *Bergman* gives the name of *elective attractions*.

Theſe reſearches are publiſhed in form of a theſis ſupported by Mr. *Arvidſon*, and printed at Upſal in 1776. The proceſs to obtain this concrete acid of ſugar, conſiſts in diſſolving one ounce of ſugar in three ounces of good nitrous acid, and in drawing off afterwards the greateſt part of this acid by diſtillation in a retort, with a moderate degree of heat, till the liquor acquires a duſky brown colour. Mr. *Bergman* pours again upon this liquor three ounces more of good nitrous acid, and repeats the diſtillation, or rather the abſtraction, till no more of the ſmoking coloured nitrous acid paſſes into the receiver. He obtains, when the reſiduum of the liquor is cooled, a ſalt conſiſting of priſmatic cryſtals, which when drained upon brown paper, weighs one gros and 55 grains.

The liquor which floats above the cryſtals, being treated in the ſame manner at different times, with freſh nitrous acid, the quantity of the acid being diminiſhed each time, ſtill yields ſimilar cryſtalls, which being purified by ſolution, filtration, cryſtallization, and draining, form a total product of acid of ſugar in the proportion of three parts to thirty parts of the ſtrong nitrous acid employed in the operation.

This proceſs of Mr. *Bergman* ſucceeds very well, and has been verified by Mr. *Sage*. This concrete acid of ſugar has the appearance, the acidity, and ſeveral of the properties of ſalt of gooſeberries. Mr. *Bergman* has examined all the combinations that it forms with ſaline, alkaline, earthy, and metallic ſubſtances, and has very fully related the reſults in the diſſertation above quoted, to which I refer. I ſhall only ſay, that we find from Mr. *Bergman*'s experiments, that this acid is in general very ſtrong and very fixed, and that it combines ſo intimately with earthy and metallic ſubſtances, that moſt of the ſalts which it forms with theſe baſes are inſoluble, or very little ſoluble in water; that it ſeparates the

ſtronger

ſtrongeſt acids from almoſt all metals; and, what is more extraordinary, is, that it decompoſes gypſum and ſelenites even without heat. If ſome of this acid be put into water ſaturated with gypſum or ſelenites, it occaſions a precipitation, which is nothing elſe than an inſoluble ſalt reſulting from its combination with the earth of gypſum and ſelenites, from which it conſequently ſeparates the vitriolic acid.

Mr. *Bergman* makes a very happy and important application of this powerful affinity of the acid of ſugar with calcareous earth, to the theory of the fabrication of ſugar. This excellent chemiſt has aſcertained by experiments, that the acid of ſugar, and even the other vegetable acids added to a ſolution of ſugar prevent abſolutely its cryſtallization. Thence he concludes, that the difficulties which occur in boiling and cryſtallizing the juice of ſugar-canes, proceed principally from the ſuper-abundance of acid that is in ſugar, as well as in other ſaccharine juices; and conſequently, that the beſt addition which can be made to it to effect this cryſtallization is that of quick-lime, the utility and neceſſity of which are evinced by experience. The reaſon of it is, that this earth, at the ſame time that it abſorbs powerfully the ſuper-abundant acid of the ſugar, forms with it an inſoluble ſalt, which either precipitates or riſes with the ſcum. The ſaline alkalies do indeed abſorb, in the ſame manner as quick-lime does, the ſuper-abundant acid, but they form with it ſalts which remain diſſolved in the liquor, and do not ſeparate like the ſalt with baſis of calcareous earth.

Mr. *Bergman* is a chemiſt too intelligent not to perceive an objection which may be made to his account of the acid of ſugar. It may be ſuppoſed that this acid is not the proper acid of ſugar which pre-exiſted in this mixt before the application of the nitrous acid, but a new combination, reſulting from the union of this latter acid with ſome of the conſtituent parts of ſugar. The anſwers of Mr. *Bergman* are taken from the compariſon which he makes of the properties of his new acid with thoſe of the nitrous acid: he ſhews, that excepting the general properties of all acids, the acids of ſugar and of nitre, not only do not poſſeſs any peculiar properties that are common to them both, but alſo thoſe properties which diſtinguiſh each of them, are very different and oppoſite to each other.

One of the moſt important objects of Mr. *Bergman*'s reſearches is, that they prove that ſugar properly ſo called is not the only ſubſtance whence this acid may be obtained from all the ſaccharine juices, flours, gums, and probably from all ſubſtances that are nutritive and ſuſceptible of the ſpirituous fermentation.

The uſes of ſugar and all ſaccharine ſubſtances are very extenſive and important. Theſe ſubſtances may be conſidered as the baſis and primary matter of all alimentary bodies, and of all kinds of wines and vinous liquors; and to cryſtallized and purified ſugar, every

every body knows the infinite advantage that we receive from it, by the improvement it gives to the taste of almost all our aliments, and by its preserving property, without which we should want many of the most agreeable and essential of the culinary and pharmaceu- preparation.

FINIS.

# A TREATISE ON THE VARIOUS KINDS OF PERMANENTLY ELASTIC FLUIDS, OR GASES.

The SECOND EDITION, *revised.*

*LONDON,*
Printed for T. CADELL, and P. ELMSLEY, in the Strand.

M,DCC,LXXIX.

To

The Rev^d JOSEPH PRIESTLEY, LL.D. F.R.S.

The following *Treatise* on permanently elastic Fluids

Is Inscribed

By the *Author*;

As a small Tribute justly due to the *Philosopher*,

Who, by the *Zeal*, *Sagacity*, and *Success*,

With which he conducted his *Experiments* on these Fluids,

Has opened

Many New and Rich Sources of Knowledge

in

*Natural Philosophy*.

# PREFACE.

THE following ſheets are intended as an *Appendix* to the ſecond Engliſh Edition of M. *Macquer's Dictionary of Chemiſtry*, inſtead of the article *Fixable Air*, which was added to the former edition. This ſubject has been lately ſo ſucceſsfully cultivated, ſince the writing of that article, that a reviſal and large additions were neceſſary: but theſe not having been finiſhed in time for inſertion into their proper alphabetical place, when the ſecond edition of the Dictionary was printing, and being beſides too large for an additional article, the following Treatiſe is ſubjoined as an Appendix to that work.

The name of the ſubject is changed from thoſe commonly employed by Engliſh authors, viz. *Fixable*, *Fixed*, or *Factitious Air*, to that of *Gas*; a word applied to diſtinguiſh permanently elaſtic fluids by *Van Helmont*, who firſt diſcovered, or, at leaſt, deſcribed more clearly

than his predeceſſors, many kinds of theſe fluids. The impropriety of applying the word *Air* to all permanently elaſtic fluids is evident, from conſidering that this word has been immemorially appropriated to expreſs only one of theſe, namely, the atmoſpherical fluid, and that the other elaſtic fluids are very different in moſt of their properties, although they have been frequently confounded with it. The impropriety would not be greater, if all *liquids* were confounded under the name of *Water*. And probably the firſt diſcoverer of other liquids committed this impropriety. Oil he might call inflammable water; and vinegar, acid water.

The application of the word *Air* in a *generical* ſenſe to expreſs all permanently elaſtic fluids, inſtead of confining it to its ancient ſpecific meaning, denoting the atmoſpherical fluid, was introduced by *Boyle*, in conſequence of an erroneous opinion which he entertained, that all theſe fluids are modifications of the atmoſpherical fluid. This phraſeology, founded on error, has nevertheleſs been continued by the reſpectable philoſophers who have ſucceeded that author; although they were ſufficiently ſenſible of the difference between the atmoſpherical and the other permanently elaſtic fluids. Intent only on the communication of

of their own very important discoveries, they continued the language of *Boyle*, and extended it to the new fluids which occurred to them in their researches. Thus Dr. *Priestley*, in his late most successful prosecution of this subject, having observed not only many new properties of the fluids formerly known, but also discovered several new fluids, and finding that the word *Air* had been applied by his English predecessors to denote generally all permanently elastic fluids, has, in conformity with a language which appeared to be in some measure established, given to his newly-discovered fluids, the appellations of *vitriolic acid air*, *marine acid air*, *fluor acid air*, *nitrous air*, &c. And in continuing the same mode of appellation, he certainly consulted the ease of his readers, who were supposed to be conversant with the writings of his predecessors, and to whom he meant chiefly to communicate the further progress he had made in this subject.

But the circumstances under which the following Treatise is written, are so different from those of the celebrated authors who have so happily cultivated this subject, that the same reasons which may be alledged to shew the propriety of their continuance of the language of *Boyle* are not here applicable: for this subject has received so very rapid an

advancement within these few years, that it has risen from a few scattered facts, to be now one of the most important branches of Natural Philosophy; and this change is so recent, that no attempt has before been made to arrange these facts, and to give them the form and method of a science. As I have first undertaken that task, it appeared not useless to revise the expressions hitherto employed; and as a *systematic* treatise, like the following, is chiefly intended for persons beginning to study the subject, I thought that it ought to adopt that phraseology which appeared to be the most perspicuous, and least capable of misleading the judgment. But certainly the language which is entitled to this description, is that in which known and established words are applied and confined to their known and established meanings, and new words are appropriated to express new ideas. Now the word *Air* having been immemorially assigned to denote the fluid which we breathe, which is one species only of permanently elastic fluids, cannot be applied in a generic sense to the other species of these fluids, without giving the idea of *Boyle*, that they are all modifications of that respirable fluid. And accordingly I have always perceived that persons not conversant in the subject received this impression from the names *Fixed Air*, *Factitious Air*, &c.

If

f it be alledged, that as *Boyle*, *Hales*, and the Engliſh philoſophers who have written the ſubject, have uſed the word *Air* in a eric ſenſe, they have thereby eſtabliſhed cuſtom. I grant that *cuſtom* is the arbiter language; but as in law, ſo in language, toms may be good or bad, according to ir extent. Now the cuſtom by which *air* been uſed in a generic ſenſe, is confined efly to a few Engliſh philoſophers: but cuſtom on which the ſpecific meaning of t word reſts, is popular, and ſo fixed in guage, that the combined authority of all philoſophers in the world could not induce nkind (when they mean to expreſs the well-own fluid which they breathe) to uſe the thets *common*, *reſpirable*, or *atmoſpherical*, which that fluid muſt be diſtinguiſhed by thoſe who employ the word *Air* in a gene- ſenſe. While therefore that word is ſo ployed, the philoſophical language will be variance with the popular language, and e acquiſition of ſcience be thereby ob-ucted.

When *Van Helmont* obſerved that there were any fluids, beſides air, which were poſſeſſed a permanent elaſticity, and that the pro-erties of theſe fluids were different from thoſe air, he very properly gave one name to the whole

whole genus of ſuch fluids, and diſtinguiſhed the ſeveral ſpecies by deſcriptive epithets added to the common generical name. And as he ſeems to have been the firſt who had the idea of a genus of permanently elaſtic fluids, (his predeceſſors conſidering all but air as condenſable vapours) he accordingly applied a new word to ſignify this new idea. And in this conduct, he followed the example of all thoſe who have arranged natural ſubſtances into genera and ſpecies. The word which he applied to denote the genus of permanently elaſtic fluids, is *Gas*, and the epithets which he added to this word to diſtinguiſh the different ſpecies, are, *ſylveſtre*, *flammeum*, *ventoſum*, &c. According to *Junker*, (Conſpectus Chemiæ, Tabul. XIV.) *Van Helmont* derived the word Gas from the German *Gaſcht*, or *Gaſt*, which ſignifies a frothy ebullition or eruption of wind, ſuch as accompanies the expulſion of gas from fermenting or effervefcing ſubſtances. In this reſpect the etymology is not exceptionable; but perhaps the principal advantage of the word is, that its etymology is ſo far from being obvious, that it cannot lead to any erroneous opinions.

In this application of the word *Gas*, *Van Helmont* has been followed by many of the foreign chemiſts, and among others, by M. *Mac-*

*Macquer*, the author of the Dictionary of Chemistry. But as this Treatise is intended principally as an Appendix to the English translation of that work, the same language ought to prevail in both, and this consideration too was an additional reason to induce me to adopt the present phraseology.

It has indeed been lately suggested that *Van Helmont* did not distinguish permanently elastic fluids from condensable vapours and exhalations. But I think a very different opinion will be formed on examining his works, in which the following observations, among many others on this subject, are found.

1. Certain fluids (to which he first gave the name of *Gas)* escape from various substances and in various processes. Among the many Gases mentioned by *Van Helmont* are, the *gas ventosum*, or air; the *gas pingue*, or the fluid extricated by applying heat to inflammable substances; the *gas sylvestre*, or the fluid produced by fermenting or effervescing substances; the *gas flammeum*, or the gas produced in the deflagration of *nitre*; the *gas* produced in the distillation of *tartar*; the *gas* produced in the burning of *charcoal*; the *gas* of the *Grotta del Cane*, of *mines*, and other *subterranean places*; the *gas* produced by the *putrefaction* of animal bodies;

bodies; the matter which occasions the *plague*; the *arterial spirit of life*; and lastly, his celebrated *Archæus*.

2. These Gases *differ from vapour*, which consists of minute particles of water or other liquids, and which may be again reduced to the same bodies whence it was exhaled; whereas gases are incondensable [*quod in corpus non cogi potest visibile*; and *incoagulabile*.] *De flatibus* §. 33. *Paradox. secund.* §. 9. *Aura vitalis**. Thus he observes, that the vapour raised from spirit of nitre by distillation, is nothing but that spirit rarefied, which passes wholly into the receiver, without any gas: but that upon adding any metal soluble in that acid, a gas is formed, which is capable of bursting the strongest vessels. *De flatibus* §. 67. This gas is evidently that which is now so well known by the name of *Nitrous Air*, and which we have described in chap. X. under the name of *Nitrous Gas*.

3. The Gases *differ also from atmospherical air*, (which however he calls sometimes *gas ventosum*)

* He says indeed that the vapour of water when raised into the upper regions of the air may, by cold, be converted into gas; and that gas may, in length of time, lose its peculiar nature of gas and be converted into water. But this opinion is only a consequence of his general theory, that water and air are the two elements from which all things are formed. *Gas aquæ* §. 13. *Compos. aqu. Mistion. chim. figm.* §. 58.

*ſum)* and are not to be conſidered as air which had been pent up in the interſtices of bodies. *Complexion. atq. Miſtion. elem. figm.* §. 19.

4. Gaſes do not exiſt, as ſuch, in the bodies, whence they are expelled, but are *new productions* formed, by the action of fermentation, fire, and other cauſes, from the deſtruction of bodies, and by means of new combinations. Thus he obſerves, that the gas formed in the deflagration of gun-powder, did not exiſt in the nitre, ſulphur, and charcoal, but is formed by their action on each other, and mutual deſtruction. *Deflatib.* §. 62, 63. 67, 68. *Complexion. atq. Miſtion. elem. figm.* §. 21, &c.

It muſt however be confeſſed, that *Van Helmont*'s knowledge of theſe fluids does not ſeem to have had much foundation in experiment, or any other ſupport than the caſual obſervation of an ingenious man, more intent on framing theories than eſtabliſhing new facts. For when his doctrines became exploded, the facts he mentions were ſo neglected, that notwithſtanding the exiſtence of ſo many gaſes is aſſerted by him, I do not believe that his writings ſuggeſted the idea of any one of them to thoſe who afterwards diſcovered them: and it is now only, ſince their exiſtence has been again diſcovered and aſcertained, that we trace them

them in the works of this author, as a matter of curiosity. While therefore we applaud the sagacity of *Van Helmont*, in having observed the existence of many permanently elastic fluids, and in distinguishing them from condensable vapours, and also from air; we ought not in justice to make any abatement from the honour due to *Boyle* and his successors who afterwards discovered the existence and properties of these fluids, collected them in separate vessels, subjected them to various modes of experiment, and thence made applications to explain the phenomena of nature. I have therefore omitted making any further mention of *Van Helmont* in the following chapters, having here collected into one view the sum of what I think is due to him.

I believe the following Treatise is the first attempt to arrange the knowledge which we have acquired on this subject, the gentlemen to whom we are obliged for this knowledge, having only communicated their proper discoveries. Neither should I, at this time, when this branch of Experimental Philosophy is generally cultivated in many parts of *Europe*, and every day brings forth new truths, have thought of the present task, if it had not been a necessary supplement to the edition of the Dictionary of Chemistry now published. M. *Lavoisier* has indeed

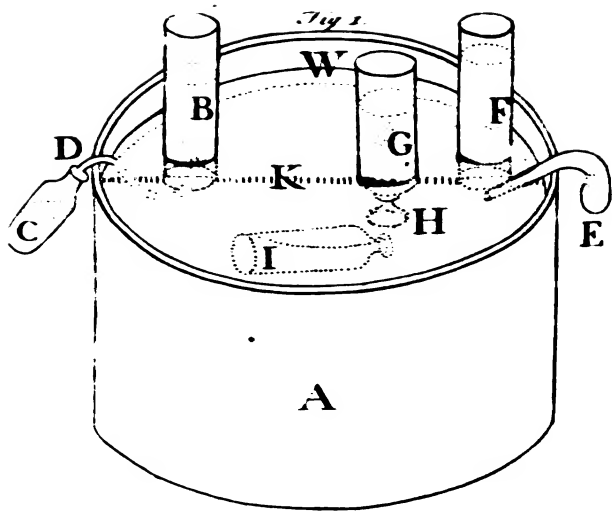
indeed given an account of the progreſs made by the ſeveral philoſophers who have advanced our knowledge on the ſame ſubject. But his plan is very different from mine. He relates the diſcoveries in the order in which they occurred to their authors; thus including in one chapter all the diſcoveries made by one man concerning many different kinds of fluids. I relate theſe diſcoveries in the order in which they are naturally connected; thus collecting into one chapter all that is known concerning one fluid; and at the ſame time aſſigning each diſcovery, concerning this fluid, to its proper author. M. *Lavoiſier*'s work is uſeful and entertaining, eſpecially to thoſe who are already converſant on the ſubject, as it ſhews how much each perſon has contributed. Mine I hope will not be leſs uſeful, as it preſents the ſcience in the order in which it is naturally connected, and in which it may be moſt eaſily attained. But while I expreſs my hope that this Treatiſe may facilitate the ſtudy of the ſubject to learners, and may even be agreeable to perſons already informed, by exhibiting under one view the principal diſcoveries and obſervations arranged under their proper heads, yet my aim is not to *ſatisfy* the curioſity of readers, but rather to *excite* it, ſo that they may recur to the ſame valuable originals, of which I have rather extracted the heads, than exhauſt-

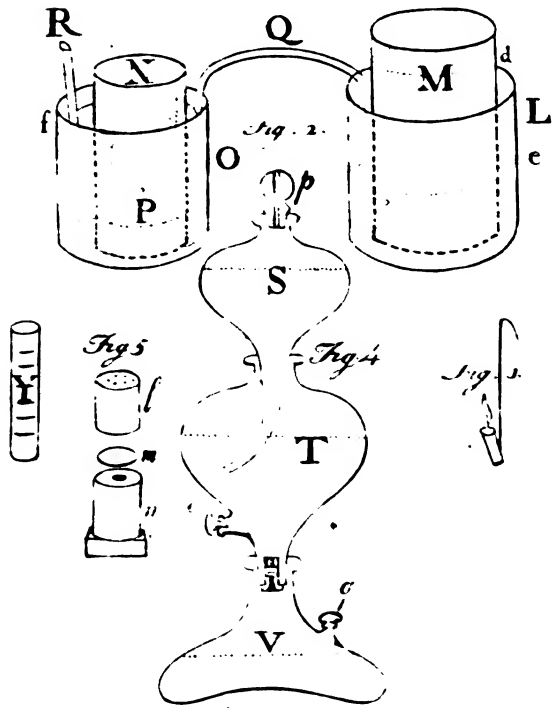
exhausted the contents; and where they will find many observations tending to confirm the principal results; many facts curious, but too detached for insertion in the following pages; and much ingenious speculation.

## ERRATA.

Page 21. *Note*. Line 12. Instead of—"a green matter which "adheres to the sides of vessels filled with water, does, in a few "hours after it is put under an inverted jar full of water, emit "a considerable quantity of *pure* air," read—"the water which "has deposited a green matter, that usually adheres to the sides "of vessels filled with water, being put into an inverted jar, "emits a considerable quantity of pure air."

Explana-



# Explanation of the PLATE.

TO ſhew the method of making experiments on the elaſtic fluids or gaſes deſcribed in this Treatiſe, the annexed plate and the following explanation are added.

The gaſes ought to be contained in jars, or other glaſs veſſels, B, G, F, (*Fig.* 1.) whoſe mouths are inverted into water or ſome other viſible fluid, that the gaſes may be kept ſeparate from the atmoſpherical air, and that their bulk may be diſtinguiſhed.

When a jar, as B, is intended to receive any gas, it ought to be previouſly filled with water; and its mouth inverted into another larger veſſel, containing alſo water, ſuch as the oval or oblong wooden tub A, which ought to be raiſed ſo that it may be as high as the operator's hands. This tub, being filled with water up to W, is a very convenient veſſel for receiving ſuch inverted jars; as it affords room for ſeveral of them to ſtand in it at once; and thus the gaſes contained in them may be poured from one jar into another jar, or other inverted bottle G. If the mouth of the bottle G be narrow, the transfuſion of gas into it from another veſſel I, is facilitated by the funnel H. This method of pouring gaſes from one veſſel into another, by immerſing the mouths of the veſſels under water, is deſcribed by the Hon. Mr. *Cavendiſh*, Phil. Tranſ. 1766.

In the tub A, Dr. *Prieſtley* places a ſhelf K a little below the ſurface of the water, for the more commodious ſupport of jars containing the different kinds of gas. The jar B, which is to receive the gas, ought to be placed ſo upon the ſhelf, that one of the edges of its mouth ſhall hang over the ſhelf, and that the mouth of the glaſs tube D may be allowed to paſs under that edge; by which diſpoſition the gas iſſuing from the phial C through the tube D may riſe

 into

into the jar B. Some persons recommend to have the shelf pierced with a row of holes along its edge, and to have a small funnel with its mouth inverted fixed into each of these holes.

In order to procure gas, let the materials, which are to yield it, be put into a phial C, into the neck of which is ground a bent glass tube D: or, the tube may be made to pass through a cork fitted into the mouth of the phial, in those operations where the materials employed are not capable of corroding the cork, and thereby of altering the quality of the gas. Let the end of the bent tube which is most remote from the phial, be sunk in the water of the tub A, so that it shall be immediately under the mouth of an inverted jar B previously filled with water, and that the gas produced from the materials in the phial shall pass through the tube into the jar, in which it will displace part of the water, and be collected. If heat be required for the production of the gas, the flame of a candle or of a lamp may be applied to the bottom of the phial, which ought to be blown thin and round, that it may be less liable to crack by the heat. The above method of procuring gas is employed and described by Dr. *Priestley*, in his *Observations and Experiments upon Air.*

This operation may also be very well performed, by employing, instead of the phial and tube, a small retort E, with a long narrow neck, the mouth of which is immersed in water under the mouth of an inverted jar F. Such small retorts are very convenient, as they have no joints; and where considerable heat is to be applied, a chafing-dish with lighted charcoal may be put under their bottoms.

When a heat greater than glass vessels can sustain is to be applied, the materials are to be put into a gun-barrel, or other metallic tube, and the close end of the barrel, in which the materials lie, may be put between the bars of a common grate, among the burning coals, and to the mouth of the barrel may be fitted, by means of lute, a glass tube, the nose

nose of which may be placed under the mouth of an inverted jar previously filled with water, and standing in the tub, into which jar the gas expelled by the violent heat from the materials in the gun-barrel will pass and be collected.

As some gases are capable of being absorbed by water, such as the *acid* and *alkaline* gases, this liquid is not fit to be employed to contain them, &c. therefore quicksilver must be substituted. For this purpose Dr. *Priestley* recommends the use of a small wooden trough to contain the quicksilver, in which the same operations with smaller jars may be performed, as are above described to be done in the wooden tub, *Fig.* 1.

When a jar containing gas is to be removed from the tub, let a hollow plate, saucer, or other vessel, whose orifice is wider than that of the jar, be immersed in the tub, and slipped under the inverted mouth of the jar. The two vessels may then be removed from the tub, and the external air will be prevented by the water contained in the lower vessel from entering the jar and mixing with the contained gas. By this method any number of jars containing gas of different kinds may be set apart, for future experiments, and when there is occasion to pour any of the gas contained in them into other vessels, they must be again immersed in the tub, and the transfusion performed as before directed. When, in making experiments upon these fluids, jars containing gases of different kinds are set apart, it is necessary to ticket them, in order to prevent mistakes.

When a quantity of gas is to be transported to a distant place, a bottle may be filled with it by means of a funnel in the manner represented in *Fig.* 1. G, H; and a cork may be introduced under water into the neck of the bottle. The gas thus contained in the bottle, and secluded from the external air by means of the cork and the small quantity of water that remains in the neck of the bottle, with which the cork is kept moist, may be carried safely to any distance,

if care be taken to keep it in an inverted position.

That the gas may be mixed with as little air, as is possible, it is proper to allow the effervescence of the materials to proceed during a minute or two before the mouth of the tube or of the retort be put under the inverted jar. By this method the greatest part of the air contained in the vessels is thrown out; although some small portion will always remain. If the gas should be required perfectly free from air, the following apparatus may be employed.

Into two glass jars L and O (*Fig.* 2.) let two smaller jars M and N be inverted; and let a communication be formed between the two inverted jars, by means of a bent tube Q, each extremity of which opens into one of these jars. Under the inverted jar N, let a smaller vessel P be placed to contain the effervescing materials. The air contained in the several jars and tube is to be expelled, by plunging them into the water of the tub A, and joining them while immersed and full of water, in the order represented in the plate. The apparatus thus joined, and full of water, may be removed from the tub, and set upon a table. To prevent the water contained in the jars from running over during the effervescence, part of it ought to be drawn off from the jars L and O, by putting the shorter leg of a syphon or bent tube, previously filled with water, into either of these vessels, till the surface of the water in the outer jars be lowered to about the height of the dotted line *e*. The apparatus being thus prepared, if the matter, from which the gas is to be procured, be a liquid, as the solution of potash in water, it may be poured through the tube R into the vessel P; and an acid may be afterwards poured through another similar tube into the same vessel, where the acid and alkaline liquors mixing with the water contained in the vessel, and with each other, produce an effervescence. The gas rises towards the top of the inverted jar N, and pushes the water into the

the jar O. As more gas rises, it occupies more and more of the space of the jar N, and it gradually forces its way through the bent tube Q into the jar M, where it is collected. For, its passage through the tube Q into the jar M, is resisted only by the column of water contained in the jar L, that is, from the surface of the water at *e*, to the bottom of the jar L; whereas the escape of the gas under the inverted mouth of the jar N, is resisted by the column of water in the jar O, the height of which is measured by the distance between *f*, representing the surface of the water, and the bottom of the jar. And this column is rendered higher than the former column; because a part of the water of the jar N is forced out of it into the jar O, by the gas occupying the upper part of N. But when the gas passes into the jar M, it forces part of the contained water into the jar L, and may raise the column of water there so high, that the gas shall escape under the inverted mouth of the jar N into the open air, more easily, than it can pass through the tube Q into the jar M. It is therefore necessary, during the operation, sometimes to draw off part of the water from the jar L, by means of a syphon, that the passage of the gas into the jar M may be facilitated. When the jar M is nearly full of gas, it may be raised a little, in order to disengage it from the end of the tube Q, and may be then removed along with the jar L; and two other similar jars, one inverted within the other, and both previously filled with water, may be substituted in the place of L and M, to receive the gas which continues to pass through the tube Q. The operation may be continued by changing the jars, and by adding occasionally more alkaline or acid liquor through the tube R; and large quantities of gas obtained without any mixture of external air.

If the substance, from which the gas is to be produced, be solid, as marble, or metals, it may be put into the vessels P, before the apparatus is removed from the tub of water, and the acid liquor may be poured

poured upon it through the tube R, as above described.

If considerable heat be required to produce gas perfectly free from mixture of external air, the most accurate method of accomplishing this purpose is that practised by Dr. *Priestley* in some of his experiments, namely, to put the substance, whence the gas is to be produced, into a phial, the bottom of which is thin and round; to fill up the phial with mercury; to invert this phial into a bason containing mercury; and to throw the focus of a concave mirror, or of a lens, upon the substance, which being lighter than the mercury, will float on the surface of this fluid, under the thin bottom of the inverted phial.

To try the effect of any gas upon the flame of a candle, let a piece of wax taper be fastened to one end of a wire, as is represented in *Fig.* 3. and let the lighted taper be dipt into a small jar Y, previously filled with the gas or air to be tried.

When the diminution occasioned by mixing nitrous gas with air is to be observed, it will be proper to have two or more small jars Y, graduated with a file or diamond, each degree being equal in contents to an ounce measure of water, or to any other given bulk. By means of these graduated jars, the quantities intended to be mixed of the air and nitrous gas may be first measured separately, and the diminution, which they suffer by their action on each other, may be collected from observing the space occupied by them, after they have been mixed.

Signor *Landriani*, Abbe *Fontana*, and Mr. *Magellan*, have each invented instruments, which they call *eudiometers*, by which the diminution upon mixing air with nitrous gas, and consequently the degree of salubrity of the air examined, are intended to be ascertained more commodiously, especially upon journeys, than by the abovementioned apparatus of graduated jars. But notwithstanding the ingenuity shewn in the contrivance of these instruments, the greater simplicity of the graduated jars will, perhaps, claim the prefe-

preference. For although this apparatus requires a pretty large veſſel of water, in which the transfuſion of the air and gas is to be performed, and although it is therefore not ſo portable as the *eudiometers*, yet no inconveniency will ariſe, when we conſider the facility of tranſporting the air to be tried. For which purpoſe, nothing more is required than to carry a phial filled with water to the place, the air of which is to be examined, and to empty the phial in this place; by which means it will become filled with the air required, and by corking the phial, the air will be prevented from mixing with any other air, and may be kept till a convenient opportunity offers for trying its purity, by mixing it with nitrous gas in a graduated jar, as is above deſcribed.

*Fig.* 4. repreſents a ſection of an apparatus of glaſs veſſels, in which water may be impregnated with the gas extricated from chalk and other calcareous or alkaline ſubſtances, by means of acids. *See chap. XIV. of this Treatiſe*, §. 118. This apparatus, which was invented by Dr. *Nooth*, and is deſcribed in the *Phil. Tranſ. vol. 65th*, conſiſts of three veſſels, S, T, and V, well fitted, by grinding, into each other, in the manner repreſented in the plate; and of a glaſs valve placed in the lower neck of the veſſel T, ſo contrived, that it ſhall admit the gas, which is extricated from the effervescing materials contained in the veſſel V, to paſs from this veſſel into the veſſel T containing the water to be impregnated; but that it ſhall prevent this water from falling into the veſſel V. This valve conſiſts of three pieces, views of which are repreſented upon a larger ſcale by the figures *l*, *m* and *n*. The pieces *l* and *n* are cylinders fitted by grinding into the lower neck of the veſſel T. The lower piece *n* is perforated along the axis of the cylinder. In the upper piece *l*, there are ſeveral very ſmall perforations parallel to its axis. Between theſe two perforated cylinders is placed the piece *m*, which is a ſegment of a ſphere, and is moveable. The level ſurface of this ſegment reſts upon the upper, ſmooth, and level ſurface

face of the piece *n*, covering the perforation, and thereby preventing the water contained in the vessel T from falling into the vessel V.

When the apparatus is to be used, let the upper vessel S be disengaged, and the vessel T be filled with the water to be impregnated. Let as much water be poured into the lower vessel V as is sufficient to cover the bottom of the vessel. Some powdered chalk is to be thrown into this vessel; and then, as much acid of vitriol, as may be thought sufficient to saturate the chalk, is to be added. These effervescing materials may be put into the vessel V, either through the mouth of this vessel, after the vessel T has been disengaged from it; or, without disengaging the vessel T, through the aperture *q*, which is afterwards to be accurately closed with a ground stopper. Lastly, the vessel S is to be fitted to the vessel T. When the gas rises from the effervescing materials contained in the vessel V, it passes through the perforation of the cylinder *n*; presses upon the level surface of the lenticular piece *m*; raises this piece a little upwards; escapes into the small space between the two cylinders *l* and *n*; and thence ascends through the small perforations of the cylinder *l*, and also through the water contained in the vessel T, in the upper part of which it remains collected. When the gas enters the vessel T, it forces some of the water, contained in this vessel, to rise into the upper vessel S, which is left open, or is only closed with a perforated stopper, that vent may be given to the contained air, when the water is thus forced into this upper vessel.

The gas remaining in the upper part of the vessel T is gradually absorbed by the water contained in this vessel; and this absorption may be promoted by frequent agitation, which brings new portions of the water into contact with the gas. The absorption of gas is also promoted by the pressure occasioned by the column of water raised up into the vessel S. For pressure facilitates the absorption, as Mr. *Cavendish* has observed. The pressure might be increased to any given

given degree, by a valve (similar to the safety-valve of a fire-engine) fitted into the mouth of the vessel S; or by a mercurial gage, as has been proposed by Mr. *Warltire*, (*Exper. and Observ. vol. III. Append.*) And thus a much stronger impregnation of water with gas may be effected, than is possible without artificial compression. Cold also facilitates the absorption, as appears from the experiments of Dr. *Hales*. For the more commodious agitation of the water, Mr. *Magellan* has added to the above described apparatus two more vessels similar to S and T, by means of which the impregnation of water may be carried on at once in two sets of vessels, one of which sets is to be agitated, while the other is receiving the gas from the effervescing mixture in the lower vessel V, and thus the water in each set of vessels is alternately supplied with gas and agitated. By this method water may be impregnated with gas in a few minutes.

As the vessel V contains much air, at the beginning of the operation, it is proper to let the effervescence proceed, during some minutes, before the several vessels of the apparatus are joined together, that the greatest part of the air may be expelled, before any gas is collected in the vessel T. When the water is sufficiently impregnated, it may be occasionally drawn off at the spout *o*, by removing the stopper.

To the water thus impregnated with gas ingredients may be added to give to it the peculiar qualities of the several mineral waters. Thus by adding a piece of iron to the impregnated water, the chalybeate property of *Pyrmont* water may be communicated.

Dr. *Priestley* impregnated water, by exposing it to the stratum of gas which floats over the surface of liquors undergoing the vinous fermentation in a brewery, and by pouring this water from one vessel to another, in order to encrease its surface, and thereby to hasten the impregnation. The *Duke de Chaulnes* has shewn how very large quantities of water may be impregnated very expeditiously with the gas of a brewery, by agitating the water immersed in the stra-

tum of gas. The agitation is performed by means of an instrument composed of many pieces of wood passing transversely through a long axis, and similar to the instrument used for frothing chocolate. This instrument being put into a tub filled with water to be impregnated, is to be turned quickly and alternately from right to left, and from left to right, and thus a strong impregnation is said to be given in a few minutes. The Duke recommends that considerable quantities of water should be thus impregnated in great breweries, and put into large bottles well corked and waxed, in which it may be safely transported, and kept till it is used *.

Many

* The *Duke de Chaulnes* availed himself of the great quantities of this gas which is to be found in a brewery to exhibit, in presence of the Academy of Sciences, several of its properties more at large than had been done before, at least in *France*, where the subject is much more recently cultivated than in *England*, and he accompanied his experiments with a memoir on the phenomena produced by this gas, which will be printed in the next volume of *Memoires des Scavans Etrangers*.

The gas which he employed is that which floats on the surface of beer during its fermentation. He observes, that the atmosphere of gas which rises from this liquor fills all the upper part of the vat, in the bottom of which the beer ferments. The depth of the vat from its edge to the surface of the liquor was four feet, and this space was filled with gas unmixed, or at least, in a very small degree, with air.

The *Duke de Chaulnes* plunged a jar into this stratum of gas, as one plunges a vessel into the water contained in a bason, and he withdrew it so full of gas, that a candle was extinguished as soon as it came to be level with the edges of the jar. He then poured this gas into another jar of equal size, in the same manner as water or other liquors are poured from one vessel into another. The gas descends by this easy operation from one jar to the other, so that a candle will now burn to the bottom of the first jar, and will be extinguished as soon as it enters the second. The greater gravity of the gas than of air is thus shewn in a striking manner. Nothing can be more singular than this action of pouring from one vessel into another, where nothing appears that is thus poured, and to see nevertheless a candle instantly become extinct, an animal die in a few seconds, and an alkali made to crystallize, when they are put into this second jar, which does not seem to contain any thing.

He

Many other contrivances for the performance of particular experiments are described in the writings of Dr. Hales (*Statics*) Mr. Cavendish (*Philos. Trans.* 1766, 1767) Dr. Priestley (*Observations and Experiments on Air, three vols.*) and M. Lavoisier (*Opuscules physiques et chemiques, Vol. I.*)

He moistened the inner sides of a jar with oil of tartar per deliquium, and poured into this jar some gas. In less than a minute, these sides were covered with crystals.

By putting some caustic volatile alkali into a vessel filled with gas, and well closed, he produced a vacuum, as appeared from the fall of the mercury of a barometer, inserted into this vessel.

He filled large stone-ware bottles with this gas, by holding them during some time in the vat over the surface of fermenting liquor, and having corked the bottles, ordered them to be carried to the academy, in presence of whom he exhibited his experiments.

CON-

# CONTENTS.



A TREA-

A

# TREATISE

ON THE

# VARIOUS KINDS

OF

# GASES.

## CHAP. I:

### *Definition and Enumeration of Gases.*

1. MOST, perhaps all, substances, solid and liquid, may, by heat, more or less intense, be converted into fluids exceedingly rare, invisible, and highly elastic. Thus when water is exposed to a heat sufficient to raise the mercury in Fahrenheit's thermometer to 212°, if it be not subject to a greater pressure than that of the atmosphere, it becomes gradually changed into vapour, which is a fluid rare, invisible, and highly elastic; and the water thus changed, while it continues exposed to that temperature and pressure, retains its elastic state*.

Several

* Whenever the vapour of water becomes visible, the water is no longer in the state of vapour; but is again *condensed*, that is, reduced to its original state of a liquid; as is explained in §. 2. For fogs, and visible exhalations, are nothing but assemblages of very minute drops of water formed by the condensation of vapour; which drops are so small that they can scarcely overcome the re-

 sistance

Several ſubſtances which were formerly thought unalterable by fire, have been lately diſcovered to be ſuſceptible of evaporation, when expoſed to a heat ſufficiently intenſe. *Diamonds* have been lately ſhewn by the French Academicians to be evaporable by a heat not much more intenſe than that uſed in the cupellation of ſilver. Gold and ſilver are ſaid to have been elevated by the heat of a concave mirror †.

2. Many of the ſubſtances thus volatilized, or converted into a rare, inviſible and elaſtic fluid, by heat, may be again condenſed into concrete, or palpable and viſible ſubſtances, by expoſing them to a heat leſs intenſe than that which was neceſſary to produce their evaporation. Thus when the vapour of water is expoſed to ſome degree of heat leſs than 212°, it loſes its great elaſticity, and bulk; and is again *condenſed*, that is, reduced to its original ſtate of a liquid. All thoſe rare, inviſible and elaſtic fluids which may, by cold, or ſuch a degree of it as has been hitherto applied, be thus condenſed, are called *vapours*.

3. Several other highly elaſtic, inviſible, rare fluids cannot, by the cold of the atmoſphere, or by any degree of cold to which they have hitherto been known to be expoſed, be thus condenſed. Such is the *air* which we breathe, and ſuch are the *elaſtic fluids*, which eſcape from wine and other fermenting liquors, and from the effervescing mixtures of acids and alkalies.

Theſe

ſiſtance which the air makes to their deſcent, and therefore ſeem to be ſuſpended in that fluid. For their gravity being as their quantity of matter, and the reſiſtance of the air being as their ſurfaces, it follows, that the ſmaller the drops are, the more reſiſtance will be given to their deſcent through the atmoſphere.

† Buffon, Supplement, Tome 3me.

These *Fluids* are called *permanently elastic*, because they cannot, like those mentioned in §. 2, be deprived of their elasticity by cold *. They are also called GAS by *Van Helmont*, who discovered many of these permanently elastic fluids, and comprehended the whole genus of these fluids under this appellation; while he distinguished the several species, by adding descriptive epithets to the generical term; as *gas sylvestre*, *gas ventosum*, *gas flammeum*, &c. †

4. A GAS may therefore be *defined* "AN EXCEEDINGLY RARE, HIGHLY ELASTIC, INVISIBLE FLUID, "NOT CONDENSABLE BY COLD."

By this definition a Gas may be distinguished from other substances. The elasticity of gases is so great, that they can support the weight of the incumbent atmosphere, and yet remain so rare, that although some are denser than others, yet they are all several hundred times lighter than water. They are distinguished from *smoke* and other *visible exhalations*, by their being invisible, and also by their great elasticity;

 and

* The Fluids called *permanently* elastic, may be fixed, absorbed, or deprived of their elasticity, by being combined with other substances. Thus the permanently elastic fluid obtained from calcareous earths, may be absorbed by water, or by the quicklime that is dissolved in lime-water; and when it is thus absorbed and combined, it is reduced to a space several hundred times less than that which it before occupied. And further, although these fluids retain their elasticity in any degree of cold to which they have been exposed, we cannot with certainty infer, that some of them might not be condensed by a more intense cold. The *permanency* of the elasticity, therefore, of these fluids is to be understood only as relative, 1st, to their uncombined state, and, 2dly, to any degree of cold to which they have hitherto been known to be exposed.

† See an enumeration of the principal gases observed by *Van Helmont*, in the preface to this Treatise.

and they are diſtinguiſhed from *vapours*, by their not being condenſable by cold.

5. The *various kinds of Gas* hitherto diſcovered, *native* or produced by *art*, are enumerated below. Theſe ſhall be treated ſucceſſively. Others will probably be diſcovered by means of future experiments and obſervations.

1. *Air.*
2. *Calcareous Gas.*
3. *Inflammable Gas.*
4. *Nitrous Gas.*
5. *Vitriolic acid Gas.*
6. *Marine acid Gas.*
7. *Nitrous acid Gas.*
8. *Fluor acid Gas.*
9. *Alkaline Gas.*

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## CHAP. II.

### *On Air.*

6. AIR is the inviſible, inſipid, inodorous, pellucid, ſonorous, reſpirable, and permanently elaſtic fluid that ſurrounds our Globe. From the permanency of elaſticity, it is comprehended in the definition given (§. 4.) of Gaſes, of which it is therefore a ſpecies, and might be called *Atmoſpherical Gas*, in conformity with the mode which we have adopted of denoting the ſeveral ſpecies of permanently elaſtic fluids by deſcriptive epithets added to the generical word *Gas*; but the word *Air* having been immemorially applied to ſignify this fluid, we ſhall, in the following pages, employ it in this popular ſenſe, and ſhall confine it to denote the atmoſpherical fluid alone. And when I ſhall have occaſion to mention thoſe reſpirable

ſpirable and permanently elaſtic fluids which may be obtained by certain artificial proceſſes, and to which the ſame name cannot be denied, as they poſſeſs all the known properties of air, I ſhall diſtinguiſh them from the atmoſpherical fluid, by adding the epithet *factitious* to the word *air* ‡. Phyſical writers have treated copiouſly on the gravity, elaſticity, and other mechanical qualities of air. Its *chemical* properties have been diſcuſſed at the article *Air* of the *Dictionary of Chemiſtry*. Here therefore ſome ſupplemental obſervations only ſhall be added, concerning its *affections* by *different ſubſtances*, and its *conſtitution*.

7. Air is capable of *combining with various ſubſtances*. Hence the atmoſphere is replete with diverſe exhalations, and with all thoſe matters which the air can diſſolve: and its properties are affected by the quantity and kind of foreign particles contained in it.

8. *Water* is one of thoſe ſubſtances which *Air is capable of diſſolving*; and accordingly more or leſs of this liquid is always contained in the atmoſphere; as appears from the moiſture imbibed by dry cauſtic



‡ The word *air* has been uſed by Mr. *Boyle*, Dr. *Hales*, Dr. *Black*, Mr. *Cavendiſh*, Dr. *Prieſtley*, and other Engliſh authors, to denote the whole genus of permanently elaſtic fluids, moſt of which differ widely, in their properties, from the atmoſpherical fluid. I have, in the preface, given my reaſons, for confining this word to its proper, antient and popular meaning, and for giving other names to the fluids which theſe authors have diſtinguiſhed by the terms, *fixed air*, *inflammable air*, *nitrous air*, &c. But to prevent any ambiguity that might ariſe from this difference of phraſeology, I have, in treating of each fluid, mentioned the names by which theſe authors have diſtinguiſhed it. Thus when they ſpeak of the fluid which is the ſubject of this chapter, they add to the word *Air*, (by which alone it is diſtinguiſhed in this Treatiſe) the epithets *common*, or, *reſpirable*.

alkali exposed to air, or from the condensation of moisture on the external surface of a vessel in which artificial cold is produced by mixture of salt and snow. Probably no part of the atmosphere is ever free from a portion of dissolved water, besides the watery particles that float *visibly*, (for water dissolved in air is invisible) forming clouds, and fogs; all which are mechanically suspended in the lighter atmosphere, as gold-leaf is in water, and not *chemically* combined with the air.

9. As water is capable of being dissolved by air, and thereby diffused through the mass of the atmosphere, so also is *air capable of being absorbed by water*, and the air thus absorbed seems to lose part of its elasticity. Thus if water be deprived by boiling of all the air or other Gas contained in it, and afterwards be exposed to the atmosphere, it will absorb some air. And if a bubble of air be admitted into an inverted bottle filled with boiled water, the whole quantity of air will be absorbed, provided the bubble of air be not larger than is requisite to saturate the quantity of water employed*.

The quantity of air capable of being absorbed by a given quantity of water, is, according to Dr. *Hales*, equal in bulk to one fifty-fourth part, and according to *Nollet*, to one thirtieth part of the water employed†.

10. *Air*

* This absorption of air by water has been generally said to occasion no sensible encrease of the bulk of the liquid. *Muschenbroek* however observes that the air absorbed by water does add a very *little* to the bulk of the water; but that any difference it may produce in the specific gravity of the liquid is so small that it can scarcely be discovered by experiment. *Introd.* §. 1481.

† We need not wonder that a substance so rare and elastic as air should be thus united to water, and by the union be deprived of the greatest

10. *Air promotes the combustion of inflammable bodies*; and the air thus employed is *altered* by the operation. Thus when charcoal or other inflammable substance is burnt, the air in which this combustion happened, becomes possessed of properties very different from those of common air,

11. *Air thus altered by burning substances becomes less in bulk* than it was before the alteration, as Mr. *Boyle* has observed. Thus, when lighted candles or other kindled substances are put under a receiver, the mouth of which is inverted and immersed in a vessel filled with water, they burn a little while, longer or shorter, according as the quantity of air is greater or less relatively to the quantity of substance actually in combustion at a time. When they have ceased to burn, the



greatest part of its elasticity; this phenomenon being consentaneous with the general analogy of chemical solutions or combinations. For in all chemical solutions, the integrant parts of one body are divided and separated by those of the other component body. Thus the particles of air are separated from each other by the particles of water. But elasticity or expansive force cannot be considered as the property of any single particle, for it implies two particles, at least, endeavouring to recede from each other. The particles therefore of air being considerably disjoined from each other, and engaged with those of water, may have their expansive power so much weakened, that they yield to the combining power of water. The elasticity however of air absorbed by water is not destroyed, but only diminished; for by the application of heat, or by removing the pressure of the atmosphere, the air gradually recovers its expansive force, and disengages itself from the water. Thus *M. de Luc* observed, when he was making thermometers with different liquors, that these liquors which had been deprived by boiling of much of their contained Air or other Gas, did nevertheless expand gradually, and rise many degrees in the stems of the thermometers, when the pressure of the atmosphere was removed, and that this expansion took place long before any bubbles appeared. See *Recherches sur la modification de l'atmosphere*, I. 230.

water within the receiver may be ſeen to riſe higher than it was before the combuſtion, as ſoon as the included air has loſt the heat which it had received from the burning ſubſtance. The greater height of the water within the receiver after the combuſtion, than before it, ſhews that the included air preſſes with leſs force on the ſurface of the water than the external air does; and conſequently that it is reduced to a ſmaller ſpace than it occupied before the combuſtion.

This *diminution of the preſſure*, or of the *bulk* of the quantity of air contained in the receiver, occaſioned by the combuſtion of inflammable ſubſtances, may depend upon a *diminution of the quantity* of this elaſtic fluid by *abſorption*, or by *precipitation* of part of it, or upon a *diminution merely of its elaſticity*, while the quantity remains the ſame. Dr. *Hales* conſiders it as a diminution of the elaſticity of the contained air: but Dr. *Prieſtley* is inclined to think, that it is a diminution of the quantity of air, ſome part being precipitated; and he is induced to form this opinion, from his not having been able to find any *conſiderable* alteration in the ſpecific gravity of the air in which candles or brimſtone had burnt. From ſeveral trials purpoſely made he thinks that this diminiſhed air was not heavier, but rather lighter than air which had not been diminiſhed. *Exp. and Obſ. on Air*, I. 46 *and* 267. II. 94.

Dr. *Hales* obſerved that the *air continued to diminiſh* under the receiver ſeveral days after the extinction of the candles. This continued diminution may probably have been occaſioned by a gradual abſorption of ſome part of the air by the water in which the inverted receiver was immerſed; for Dr. *Prieſtley* remarks, that "this diminution of air by burning is not always im-"mediately apparent, till the air has paſſed ſeveral

"times

"times through water; and that when the experi-
"ment was made with veſſels ſtanding in quickſilver
"inſtead of water, the diminution was generally in-
"conſiderable till the air had paſſed through water."
*Exper. and Obſerv. on Air, vol.* I. 46.

Air altered by burning ſubſtances occaſions *a precipitation in lime-water.* It appears therefore that by combuſtion ſome Gas is produced which is capable of uniting with the quicklime diſſolved in the lime-water; and is probably the ſame which will be deſcribed in chap. 3d. under the name of *Calcareous Gas.* Whether this Gas proceeds from the combuſtible body employed, or from ſome precipitation of part of the air, or be a compound reſulting from the union of ſome part of the inflammable body with the air or any of its component parts, has not yet been aſcertained*. When this Gas has been abſorbed by water or by lime-water, the remaining part of the air is alſo noxious and unfit for maintaining flame.

*Air diminiſhed by burning ſubſtances is no longer capable of maintaining fire.* Dr. *Deſaguliers* obſerves that Air which had paſſed through burning coals into an exhauſted receiver immediately extinguiſhed flame.

*Air is not capable of ſuffering more than a limited diminution* by burning ſubſtances. The diminution of the bulk of a quantity of air included in a receiver in which a candle was allowed to burn as long as it could, was found by Dr. *Hales* to be equal to one twenty-ſixth part of the whole quantity of included air, and by Dr. *Mayow*

* This Gas cannot be produced from an inflammable body merely by heat without combuſtion; for when the focus of a burning glaſs was thrown on a bit of charcoal ſuſpended in a receiver filled with any other Gas than air, and inverted into a veſſel containing lime-water, no precipitation was occaſioned in the lime-water. *Exp. and Obſ.* I. 136.

*Mayow* to be one thirtieth, and by Dr. *Prieſtley* to be one fifteenth or one ſixteenth. This diminution is obſerved to vary in different circumſtances. Dr. *Hales* obſerved that air ſuffered a greater diminution in equal receivers by large, than by ſmall candles; and alſo with equal candles, in ſmall, than in large receivers. Probably the candles become extinct as ſoon as all the air in contact with, or near their flame, has ſuffered its alteration; for by other modes of combuſtion, the air has been made to ſuffer a much greater diminution. Thus Mr. *Cavendiſh* found that air was diminiſhed one tenth by paſſing through an iron tube filled with red-hot powder of charcoal. *Exp. and Obſ. vol. I.* 129.

And Dr. *Prieſtley* has diminiſhed the air much more by throwing the focus of a lens, or of a concave mirror, upon a bit of charcoal ſuſpended in a receiver. *Id. p.* 47.

I have produced a diminution equal to one ſixth part of the included air by making the candle while it burns move quickly through the different parts of the inverted receiver, and thereby bringing the flame into contact with more of the air, than when the candle remains in one ſituation till it becomes extinct.

12. *Air promotes the calcination of Metals*; and it is alſo diminiſhed by this operation, which is conſidered by Chemiſts as a ſpecies of ſlow combuſtion.

*This diminution*, like that effected by burning ſubſtances, *cannot be carried beyond a certain proportion to the whole quantity of air employed.* Accordingly, Father *Beccaria* found by expoſing filings of lead and tin to heat in veſſels hermetically ſealed, that only a part of theſe metals could be calcined, and that this part was proportionable to the capacity of the veſſels employed. [*Mem. de l'Acad. de Turin* 11.]

After

After the air has suffered its utmost diminution by calcining metals, it is no longer capable of promoting any further calcination.

The *diminution of Air by the calcination of metals* has been found by Dr. *Priestley* to be equal to one fourth of the whole quantity of air employed. Vol. I. p. 134.* But M. *Lavoisier* estimates this diminution only at one fifteenth or one sixteenth.

Air diminished by calcination differs from the air diminished by burning substances in this respect, that it *does not occasion a precipitation in lime-water*, the reason of which difference is assigned by Dr. *Priestley* to be, that the calx seizes the part of the air, which is precipitated, in preference to the lime. Vol. I. p. 136.

The water however over which metals have been calcined acquires a yellowish tinge, and an exceedingly pungent smell and taste. *Id.* 135.

13. *Metals acquire weight by calcination*, and the air which has assisted in this process, is thereby diminished. These facts seem to shew that something is absorbed during calcination by metals from the air †.

This absorption of air, or of some part of air, is further rendered probable from the elastic fluid that has

* This very great diminution of air was effected by throwing the focus of a burning mirror or lens upon bits of lead and tin suspended in a glass receiver.

† The first person who ascribed the acquisition of weight by calcining metals to the absorption of air was *Jean Rey*, who has written expressly on this subject, in a book entitled, *Essais de Jean Rey Docteur en Medicine, sur la recherche de la cause pour laquelle l'Etain et le plomb augmente de poids, quand on les calcine.* A Bazas 1630. This author attributes the encrease of weight to the adhesion of the denser part of the air to the calxes, while the more subtile part of this fluid, which prevents the adhesion of the air to other substances, is separated during the calcination.

has been obſerved to eſcape during the reduction or revival of metallic calxes, and from the loſs of weight ſuſtained by them during that operation.

14. *Air* is *diminiſhed* by exhalations of *liver of ſulphur*, and of various *inflammable ſubſtances.*

Mr. *Boyle* relates that a quantity of *air was totally abſorbed by oil of turpentine* and *ſpirit of wine* mixed together. [*Boyle's works, vol. V. p.* 113.] Dr. *Prieſtley* has alſo found that oil of turpentine poſſeſſes the power of diminiſhing air in ſo great a degree, that in one experiment one fourth only, and in another experiment only one ſixth of the original quantity of air remained. *Vol. III. p.* 92. Dr. *Hales* found that air was abſorbed by the *pyrophorus of Homberg*; and Dr. *Prieſtley* obſerved that diminutions of air were occaſioned by *liver of ſulphur*; by a cement compoſed of *turpentine and bees wax*; by *white paint*; and by *red lead and oil.* Vol. II. p. 182.

Dr. *Hales* found that a mixture of *ſulphur and filings of iron* formed into a paſte with water diminiſhed air; and the diminution has been eſtimated by Dr. *Prieſtley* to be equal to one fourth or one fifth of the air employed. [*Exp. and Obſerv. vol. I. p.* 105.] This diminution was equal, whether the experiment was made over mercury or over water. The diminiſhed air was found to be lighter than pure air; and it did not precipitate lime-water; the cauſe of which has been attributed to the acid of the ſulphur diſſolving the lime, and thereby preventing its precipitation. [*Exp. and Obſerv. vol. I. p.* 105.]

15. *Air is diminiſhed by expoſure to putrefying ſubſtances.* At firſt an elaſtic fluid is frequently generated, by which the bulk of the air is encreaſed *, but in eight

* *See Chap. XI.*

eight or ten days, the air is reduced to about four fifths or five sixths of its original dimensions. [*Id. vol. I. p.* 78.]

16. *Air is diminished by respiration of animals*, as Mr. *Boyle* first observed. Vol. IV. p. 122. The diminution was found by Dr. *Hales* to be about one thirteenth of the whole air employed.

Air diminished by respiration *precipitates the lime contained in the lime-water*, as Dr. *Macbride* observed.

17. Various other substances and mixtures have been observed to diminish air, among which are the following:

*a.* *Lime* mixed with *water*. *Hales.*

*b.* *Lime* mixed with *Sal Ammoniac*. *Hales.*

*c.* *Lime* mixed with *Acids*. *Hales.*

*d.* *Marine acid* extricated by pouring vitriolic acid on sea-salt, or on sal ammoniac. At first some fluid was generated, probably that which is treated of in Chap. VII. under the name of *Marine acid gas.*

*e.* *Volatile alkali* mixed with *iron*. *Hales.*

*f.* *Volatile alkali* mixed with *copper*. *Hales.*

*g.* *Iron* filings mixed with *water*. *Hales.* M. *Lavoisier* found that the diminution of air by iron-filings and water amounted to one fourth part of the air in the space of two months; and Dr. *Priestley* observed, that the air thus diminished could not be further diminished by nitrous gas. *Exp. and Obs. vol. II. p.* 182.

*h.* Dr. *Hales* observed that air was diminished in the *distillation of aqua-fortis*, and by the mixture of *aqua-fortis* with *copper ore*, or with *pyrites*, or with *coal.* And Dr. *Priestley* has found, that even the pure colourless nitrous acid vapour does, in length of time, phlogisticate air.

*i. Vo-*

*i. Volatile sal ammoniac* during its sublimation. *Hales.*

*k. Sulphur subliming. Hales.*

*l. Vinous Gas. Boyle III.* 144. *See Chap. III.* §. 35.

*m. Nitrous Gas. Hales. See Chap. V.*

*n. Electric sparks.* The electric spark being made to pass through a quantity of air included in a glass tube, in which also was contained some water tinged blue with turnsole, diminished the air one fifth, and changed the blue colour of the liquid to a red. *Exp. and Obs. vol. I. p.* 184. When the electric spark was taken in air over lime-water, the lime was precipitated. *Id.* 186. And when the electric spark was taken in air and in a vessel containing some caustic vegetable alkali, the alkali became crystallized. *Rozier. Aug.* 1777.

*o. Concentrated vinegar.* Exp. and Obs. vol. II. p. 27.

*p. Nitre*, which has been melted, during its cooling, was observed by Dr. *Priestley* to injure common air. *Vol. II.* 167.

*q. Vitriolic acid Gas* was observed by Dr. *Priestley* to injure common air. *Vol. II.* 209. See Ch. VI.

*r. Bolognian Phosphorus* diminishes and phlogisticates air in a remarkable degree. But the *Phosphorus of Urine* produced this effect very slowly and in a small degree, as has been observed by *Signor Alexander Volta.* Exp. and Observ. vol. III. 381.

*s.* Air is diminished by *Diamonds* exposed to violent heat. M. *Lavoisier* observed that 60 cubic inches of air, in which four grains and a half of diamonds were exposed during 16 minutes to the focus of Tschirnhausen's great lens, suffered a diminution of eight cubic inches. The air thus diminished precipitated the lime contained in lime-water. *Mem. de l'Acad.*

*des*

*des Sciences à Paris*, 1772. This experiment, together with the flame obſerved in diamonds expoſed to heat under a muffle, and the preſervation of diamonds in the fire by inveloping them in powdered charcoal, ſeem to decide the queſtion, lately agitated in France, in the affirmative, whether the effect of fire on diamonds be a real combuſtion. *See the Dictionary of Chemiſtry, article Diamonds.*

18. Air which has been once diminiſhed to its utmoſt by any one of theſe proceſſes cannot be further diminiſhed by a repetition of that proceſs, or by any of the other diminiſhing proceſſes. *Exper. and Obſervat. vol. I.* 132.

19. Air may be *totally* and almoſt *inſtantaneouſly* abſorbed by *charcoal* heated red-hot, or which has been heated red-hot, and extinguiſhed without expoſure to air in quickſilver. The quantity of air which may be thus abſorbed or devoured is many times the bulk of the charcoal employed. The ſame effect is produced by charcoal, thus prepared, upon the other permanently elaſtic fluids. This very aſtoniſhing fact has been lately diſcovered by the *Abbé Fontana*, and communicated to me by Dr. *Prieſtley*. In order to repeat this experiment, let a jar partly filled with quickſilver and partly with air, or other elaſtic fluid, be inverted into a baſon of quickſilver, and let pieces of charcoal, which have been previouſly made red-hot and extinguiſhed in quickſilver, and which have not been expoſed to air, be ſlipped under the jar, in which it will aſcend through the quickſilver till it comes into contact with the air included in the jar, part or all of which air, according to its quantity relatively to the quantity of charcoal, will almoſt inſtantaneouſly diſappear. The *Ablé Fontana* has made many experi-

experiments in consequence of this discovery, a relation of which, whenever he publishes them, cannot fail of being very interesting.

20. *Air is necessary to animal life*, as is well known from the fatal effects of enclosing animals in exhausted receivers, or in receivers filled with any other gas or vapour. Some insects however are said to live well in vacuo. *Muschenb. Introd. ad Phil. Nat.* §. 2167.

The air that has once served for the respiration of animals is unfit to be again respired, and is *fatal to life*. The *quantity* of air employed for respiration by a man is computed by Dr. *Hales* to be a *gallon* in every *minute*.

From the noxious quality of respired air, may we not explain the facts related by travellers, that animals are killed by the breath of whales, and especially by the breath of an immense serpent that inhabits the banks of the river Amazon *; the air respired by these very large creatures being sufficient totally to invelope smaller animals, and to exclude the air during a small portion of time, which, however, is sufficient for this noxious air to produce its fatal effect? If it be objected, that air, by having been respired only once, does not appear, from experiments hitherto made, to be so far vitiated, as to become capable of destroying life; may it not be answered, that the air, by being exposed to a much greater surface of lungs, and perhaps during a longer time, in these very large animals than in men, may probably suffer a much greater degree of injury, and be more completely phlogisticated? Perhaps also the effluvium and smell of the breath of these large animals may be peculiarly offensive to the organs of sensation of other animals, which

* See *Don Ulloa's Voyage.*

which they may affect in the ſame manner as the exhalations, deſcribed in §. 22. do when reſpired.

The more denſe the air is, the longer it is capable of ſuſtaining the life of animals, as appears from the experiments of Mr. *Boyle*. Nevertheleſs, a *rarefied air*, provided it be frequently renewed, ſuſtains life very well. *Condamine* lived ſeveral weeks upon the Peruvian mountains, where the air was ſo rare that the mercury of the barometer was no higher than fifteen inches and nine lines*. An *air* alſo *exceedingly denſe* may be with ſafety reſpired. Divers ſometimes breathe under bells an air nine times denſer than the air of the atmoſphere.

21. Not only the air diminiſhed by reſpiration is *noxious* to animals; but alſo the *air in which inflammable ſubſtances have burnt*; the air in which *hepar of ſulphur*, and *fumes of inflammable ſubſtances* have exhaled; the air in which ſubſtances have undergone the *putrefactive fermentation*, and probably all other kinds of *diminiſhed air*, are *noxious* to animal life †, *extinguiſh flame* †, and are incapable of *diminiſhing nitrous gas*, which is a diſtinguiſhing property of air.

 From

* See *Bouger's Voyage to Peru*.

† Nevertheleſs, Mr. *Boyle* obſerved that animals lived *nearly* as long in air in which candles had burnt, as in the ſame quantity of freſh air, and Dr. *Prieſtley* confirms the obſervation by his own experiments. Hence it appears that animals can bear a greater degree of depravity of air than is generally occaſioned by the burning of candles. But although flame be generally extinguiſhed when the air has ſuffered an inconſiderable diminution, yet by throwing the focus of ſolar rays on a bit of charcoal, the air may, by means of combuſtion thus promoted, be diminiſhed as much as it can by any other method, that is, one fifth of the whole quantity, as Dr. *Prieſtley* has ſhewn.——It cannot be doubted, that air thus diminiſhed as much as it can be by burning ſubſtances, is noxious and fatal to animal life. See §. 11.

From the many inſtances of the diminution of air by combuſtion, calcination and other proceſſes, in which the phlogiſton contained in bodies is ſuppoſed to be ſeparated from them, or merely by expoſing air to phlogiſtic vapours, it appears that the alteration produced in the air is effected by the phlogiſton of theſe bodies combining with the air, or otherwiſe operating upon this fluid: and the air thus altered is accordingly called *phlogiſticated air*. With this phlogiſticated air is generally mixed a ſmall portion of a gas which precipitates the lime contained in lime-water, and therefore ſeems to be the ſame which will be deſcribed in *chap.* III. under the name of *calcareous Gas*. And although in ſome inſtances, as in the calcination of metals, this gas does not appear, yet we cannot thence infer that it is not produced, becauſe it may be abſorbed by the calcining metals, or other ſubſtances employed. *See* §. 11 *and* 12.

22. Almoſt all exhalations, vapours, and fumes, when in conſiderable quantity, make the air unfit for reſpiration. The vapour of pure water threw a bird into great anxiety; the vapour of vinegar had the ſame effect; vapour of ſpirit of wine killed a bird; and the vapours of oil of turpentine, oil of olives and of ſpirit of ſal ammoniac, were alſo found to be fatal to life. *Muſchenb. Introd. ad Philoſ. Nat.* §. 2049. The vapour of newly plaſtered walls and of granaries are known to be noxious. *Laghius* found that the ſmell of camphor and of muſk was fatal to animals. *Comm. Bonon, tom.* 3. We ſhall hereafter ſee that every ſpecies of Gas, air excepted, is noxious; and, they have been all obſerved to be more ſuddenly fatal than a vacuum is: hence, it is evident, that their noxious quality does not depend merely on their preventing the

the access of air, or from their want of any principle, which may be supposed to render air necessary to life, but also from some instant and immediate effect on the organs of sensation. Animals may be rendered less sensible of the disagreeable impression, and less liable to be injured, by being gradually habituated to it, as Dr. *Priestley* has observed. *Exper. and Observat. vol. I.* 72.

23. Some attempts have been made to *restore vitiated air*, and render it again fit for respiration. Dr. *Hales* says that he cleansed air, which had been respired, by making it pass through flannel imbibed with salt of tartar; and that he prolonged the combustion of a candle in a given quantity of air by the same operation. The flannel employed gained weight, probably by absorbing the calcareous gas which is produced by combustion or by respiration, as has been observed, §. 11 and 21. But as in air vitiated by respiration or by burning substances, not only this calcareous gas is noxious, but also the residuum after this gas has been separated by being absorbed in water, is found to extinguish flame, and to be incapable of sustaining life, the above method of Dr. *Hales* cannot be very effectual. Dr. *Priestley* says, that by *long-continued agitation in water*, he has restored air vitiated by respiration, putrefaction, combustion, calcination of metals, a mixture of filings of iron with sulphur, or by white paint. Was this melioration produced by the water separating the vitiated part of the air from the rest by absorption; or by the agitation effecting a kind of circulation between the external air and the vitiated air included in the jars, by which means much of the former might be received into the vessels, while part of the latter might

be abſorbed by the water and thrown out into the open air ‡?

The *Count de Saluces* pretends, that air injured by combuſtion can be meliorated by *cold* and by *compreſſion*. But Dr. *Prieſtley*, from experiments purpoſely made, has refuted that pretenſion. *Exp. and Obſ. vol. I.* 48.

24. *Air is neceſſary to vegetation* or the *life of plants*. In vacuo, plants do not grow, and ſeeds buried too deep under ground do not vegetate.

M. *Cygna* affirms that plants included in a given quantity of air diminiſh this fluid, and ſoon languiſh and die; and that if other plants be afterwards introduced into the ſame receiver, they preſently die without occaſioning a further diminution of the air. Nevertheleſs, it appears from Dr. *Prieſtley*'s experiments that plants can live long in confined air without ſenſibly diminiſhing or rendering the air unfit for maintaining flame or animal life. A ſprig of mint having been put into a glaſs jar inverted into a veſſel of water, during ſome months, the air was found not to be vitiated. *Exp. and Obſ. vol. I.* 5.

Dr. *Prieſtley* found that plants grew not only in confined air, but alſo in air vitiated by the flame of a candle, or by reſpiration: and even that the vitiated air was frequently reſtored, or at leaſt meliorated by the vegetation of the included plants. He put ſprigs of mint growing in water into different veſſels filled with air, in ſome of which candles had burnt till they ſpontaneouſly became extinct, and in others the contained air had been reſpired, and he found that after the plants had been growing a few days, the contained air was ſo much meliorated that candles burnt in it, and animals

‡ Dr. *Prieſtley* has found that pure air is conſiderably depraved by agitation in the pureſt water. *Vol. II.* 96.

animals could respire it. (*Vol. I. p.* 51.) From these experiments he infers, that *vegetation is one of the means employed by nature to purify air tainted with respiration, putrefaction, or combustion* *.

But plants can tolerate only a certain degree of injury to the air in which they are placed; for Dr. *Priestley* relates, that when growing sprigs of mint were put into air strongly and recently tainted with putrefaction, they *presently died.* Vol. I. p. 86.

It is not however improbable that plants are capable of resisting a certain and even a considerable degree of putrid taint infecting the air; for several kinds of plants and also animals are known to inhabit those places chiefly where a putrid effluvium prevails, which they sustain without injury, and even perhaps with advantage



* Dr. *Priestley* has, since his last publication on air, been so obliging as to acquaint me, that his late experiments confirm his opinion of the power of vegetation in purifying the atmospherical fluid, although he acknowledges, with his usual candour, that he has also met with many exceptions. He has not only meliorated phlogisticated air, by means of growing plants, but he has also, by the same means, greatly encreased the purity of atmospherical air, so as to make it approach to the state of the pure factitious airs described in the following part of this chapter. Among the many discoveries with which the labours of this zealous and sagacious philosopher are in a singular manner crowned, one of the most extraordinary is, that a green matter, which adheres to the sides of vessels filled with water, does, in a few hours after it is put under an inverted jar full of water, emit a considerable quantity of *pure* air, like those airs obtained by factitious processes described in the following part of this chapter. He has also found that the air contained in the bladders of several kinds of sea-weeds, while the plants are fresh, is considerably better than atmospherical air. In the *Epilobium hirsutum*, or the *Willow plant*, he has discovered a singular property which it possesses, namely, that of *absorbing* considerable quantities of air, and of other permanently elastic fluids.

to their peculiar conſtitutions. Further, animals and vegetables, while living, ſeem to poſſeſs ſome peculiar property of reſiſting putrefaction. For animals are known to live many days without food, and without any appearance of putrefaction, which however begins to take place a few hours after death. Alſo, vegetables are endowed with a ſimilar power; for the water in which plants grow, though it contain much vegetable putreſcent matter, does never putrify, while the plants live and are in health; but no ſooner is the life or the health of the plant deſtroyed, than the putrefaction begins. This fact is popularly known to perſons who keep ſprigs of mint, hyacinths or other flowers, growing in glaſs veſſels filled with water.

Hence the plants which grow in ſtagnant waters probably retard the corruption of theſe waters. *See Exp. and Obſerv. vol. II. p.* 185; where an inſtance is given of the water of a reſervoir becoming putrid, when the reſervoir was cleanſed from the vegetable matters which grew on its ſurface and its ſides, and did not recover its ſweetneſs till more vegetable matter again appeared.

Perhaps this important fact in animal and vegetable economy may be explained, by ſaying, that *fermenting* ſubſtances do generally aſſimilate to their own nature, in a certain degree, many other ſubſtances, with which they happen to be mixed; and that the fermentations which are continually proceeding in the fluids of living animals and vegetables, overcome the putrid or other noxious ferments, if theſe be not too ſtrong, in the ſame manner as the vinous fermentation reſiſts putrefaction, according to the experiments of Sir *John Pringle* and Dr. *Macbride*. Hence the more ſtrongly theſe natural fermentations proceed, that is,

the

the more powerful is the *vis vitæ* of animals and plants, the more easily are noxious ferments overcome, and infections resisted.

The purification or melioration of the tainted air included in receivers in which growing plants were placed, may be attributed not only to the absorption of the noxious vapour by the plants themselves, but in some measure also, to the absorption of this effluvium by the water in which the receiver was inverted, and more considerably by the watery vapours or perspiration exhaled from the plant itself, which are known to be very great relatively to the small space within the receiver. These vapours may be considered as water with an exceedingly enlarged surface, and therefore capable of producing its utmost effect by absorption of the diffused noxious substance. The vitiated particles being thus absorbed by the watery vapours floating in the receiver might have been precipitated when the vapours were condensed by the evening colds; and by the constant succession of evaporation and condensation, which must have taken place in the receiver, the whole quantity of such particles may have been absorbed and precipitated, and the remaining air thereby purified.

While therefore we accede to the inference drawn by Dr. *Priestley* from his very curious experiments, that "VEGETATION is one of the means employed by "nature to purify air tainted by respiration, putrefac-"tion, or by combustion;" may we not ascribe a considerable share of this grand and important effect to EVAPORATION, whose operation is more extensive, penetrates to greater heights, prevails on the middle of the ocean and in frozen regions where few vegetables appear; and may not plants be also conducive to this

effect in a great meaſure by exhaling vapours abundantly, and be, in this reſpect, conſidered as inſtruments of evaporation?

The vitiated particles in the air thus abſorbed by the copious vapours which exhale from the ſurface of the earth and of the ocean, are raiſed along with theſe into the higher regions of the atmoſphere, and thence again fall along with the condenſed vapours or rain upon the earth. Thus diffuſed and united with water, perhaps reſolved into their component parts, they are not hurtful to animals and vegetables, but enter probably along with the water into their veſſels, combine with their fluids, and conſtitute part of their ſubſtance. From the animal and vegetable matters, theſe particles may be again expelled by various fermentations, putrefaction, and combuſtion; and thus, like moſt other kinds of matter, may undergo a perpetual circulation.

25. Several methods have been diſcovered by which *air*, or, at leaſt, fluids poſſeſſing all the known properties of the atmoſpherical fluid, may be *produced by art*. For this important diſcovery, which leads to a knowledge of the conſtitution of the atmoſphere, we are indebted to Dr. *Prieſtley*.

He found, that after he had abſorbed by long-continued agitation in water as much as he could of the ſeveral kinds of gas, ſuch as the inflammable gas, and that obtained by mixture of calcareous or alkaline ſubſtances with acids, (called by him and other Authors *fixed Air*) that the reſiduums had the properties of air, and he thence infers that *common air is thus generated* *. Exp. and Obſ. vol. I. p. 40. 68.

26. By

* This inference ſeemed to me to be liable to two objections. 1. In the apparatus deſcribed for procuring theſe gaſes, there muſt always have been ſome ſmall portion of common air mixed with the

26. By expoſing *red lead*, or *calcined mercury*, to the focus of a burning glaſs, Dr. *Prieſtley* expelled from theſe ſubſtances a permanently elaſtic fluid, which not only poſſeſſed all the known properties of atmoſpherical air, but in which all theſe properties appeared in a more eminent degree than in the atmoſpherical fluid

the gas. [*See Plate, fig.* 1.] 2. By a long-continued agitation of the gas in water expoſed to the atmoſphere, there would probably be ſome particles of external air continually abſorbed by the water, and afterwards ſeparated from the water into the veſſel containing the gas. In order to obviate theſe objections, I procured ſome gas from chalk and oil of vitriol, by means of an apparatus previouſly filled with boiled water, ſo that no air could be mixed with the gas obtained; [*ſee Plate, fig.* 2. *and explanation*;] and I let the gas remain expoſed to a conſiderable ſurface of clean boiled water till nine tenths were abſorbed by the water, without agitation. I paſſed this reſiduum four times through lime-water, till it occaſioned no more precipitation of the lime, by which operation, it was further reduced to a third, that is, to a 30th of its original quantity. This laſt reſiduum I found to be air ſo pure, that a candle burned in it, and that it diminiſhed as much nitrous gas as common air does. This production of air from calcareous and alkaline ſubſtances, is a very remarkable phenomenon, and deſerves further inveſtigation. I found that the reſiduum of gas obtained from pot aſh, and treated in the ſame manner as I had done that from chalk, had the ſame properties. The reſiduum of a gas obtained by diſtilling cream of tartar was chiefly inflammable, but ſeemed to contain ſome portion alſo of air, for a ſmall diminution was obſerved upon mixing it with nitrous gas.

But air cannot be thus produced from every one of thoſe gaſes, which, from the property they poſſeſs of precipitating the lime contained in lime-water, have been conſidered as of the ſame kind with the gas obtained from calcareous and alkaline ſubſtances, and have been comprehended under the general name of *fixed Air*. At leaſt, I found that a gas obtained by diſtilling green vitriol, which extinguiſhed flame, and precipitated the lime contained in lime-water, till it could no longer occaſion any precipitation in lime-water, left a reſiduum which extinguiſhed flame, and did not in any degree diminiſh nitrous gas, and was therefore ſimilar in its properties to the fluid called *phlogiſticated Air*.

fluid itſelf. For this factitious air did not only maintain the flame of kindled inflammable ſubſtances, but when a lighted candle or other ignited combuſtible ſubſtance was put into a veſſel containing this air, the flame was remarkably brighter, the combuſtion more rapidly excited, and a deflagration appeared ſimilar to that produced by thoſe mixtures of nitre and inflammable matters which are uſed in fire-works: Alſo, when animals were put into this factitious air, their reſpiration was much longer continued; that is, they could live much longer in a given quantity of it, than in atmoſpherical air. The diminution of nitrous gas (which is ſhewn to be a property of air, and to be an exact teſt of the purity of air, in *chap. V.*) was much greater; and the exploſion of inflammable gas much louder, by means of the factitious air, than when equal quantities of atmoſpherical air were mixed with theſe fluids. And the difference between the factitious and the atmoſpherical air appeared to be ſo great, that Dr. *Prieſtley* computes, that the former is capable of producing five or ſix times the effect of the latter fluid, in all theſe inſtances. He therefore conſiders this factitious fluid as a true and pure air, and thinks that the purity of the atmoſpherical air has been injured by the vapours with which it is always more or leſs mixed. He chiefly attributes the contamination of atmoſpherical air to the phlogiſton contained in the vapours mixed with the air, and the greater purity of the factitious fluid to the abſence of ſuch phlogiſtic vapours: accordingly, he diſtinguiſhes this factitious fluid and others of the ſame nature, which will be preſently deſcribed, by the name of *dephlogiſticated Air*.

27. The production of pure factitious air from red lead is much facilitated by addition of concentrated vitriolic acid. I put

I put 48 pennyweights of red lead into a long-necked retort, the contents of which were ten cubic inches; (*see Plate, fig.* 1. E.) and upon this red lead I poured twenty-four pennyweights of oil of vitriol. The red lead had been previouſly moiſtened with a little water, that the acid might more uniformly diffuſe itſelf through the red lead. The noſe of the retort was then immerſed under water, and over it an inverted jar filled with water was placed. The mixture of red lead and vitriolic acid became very hot, and ten cubic inches of air were ſoon thrown into the jar, without the application of external heat. Upon applying the flame of a lamp to the bottom of the retort, more air paſſed copiouſly into the jars. The quantity of air expelled from the above mixture of vitriolic acid and red lead, was found to be 36 cubic inches, after the proper allowances for the air contained in the retort had been made. If we ſuppoſe this air to be of the ſame denſity as atmoſpherical air, we ſhall find that the weight of the air obtained is about one hundredth part of the weight of the red lead employed *.

28. A.

* In the firſt Edition of this Treatiſe, I ſaid that a greater quantity of pure air might be obtained by adding vitriolic acid to red lead, than from an equal quantity of red lead alone, merely by violent heat. But Dr. *Prieſtley* has ſince been ſo obliging as to acquaint me, that he can produce as much air without addition of vitriolic acid as with it: which ſhews that the acid does not contribute to the formation of the air, as it ſeems to do in the inſtances of turbith mineral and other vitriolic ſalts, mentioned hereafter in §. 31. Nevertheleſs, the two proceſſes of obtaining air from red lead with or without vitriolic acid, are very different, and are ſimilar to the expulſion of calcareous gas, from calcareous ſubſtances by heat or by acids. For the expulſion of air from red lead is ſo much facilitated by addition of vitriolic acid, that much of the air eſcapes before any other heat is applied, than what ariſes from the mixture

28. A pure factitious air, poſſeſſed of all the known properties of atmoſpherical air, in a more eminent degree than the atmoſpherical fluid itſelf poſſeſſes theſe properties, and ſimilar in all its effects to the factitious air above deſcribed, (§. 26.) may be copiouſly obtained by means of heat from *nitrous acid* mixed with almoſt any unphlogiſticated earthy ſubſtance, as *minium*, *flowers of zinc*, *chalk*, *clay*, *gypſum*, *mag-*

mixture of theſe two ſubſtances, and the operation may be eaſily completed by the heat which glaſs veſſels can ſuſtain. The air thus produced (as in every other inſtance of the production of pure air) is always mixed with a very ſmall portion of calcareous gas, and which may be ſeparated by making the air paſs through lime-water, or, more effectually, through water in which ſome pieces of quick-lime are put; for as ſoon as the gas uniting with the lime diſſolved in the water precipitates this portion of lime, the water becomes capable of diſſolving a freſh portion of the lime; and thus the water is always kept ſaturated with the lime, notwithſtanding the precipitation produced in it. If pure factitious air ſhould be hereafter applied to medicinal purpoſes, this method of obtaining it ſeems preferable to thoſe hereafter mentioned by means of the nitrous acid; in which methods, not only a larger portion of calcareous gas is generally mixed with the pure air, but alſo conſiderable quantities of another noxious gas, namely, that which is deſcribed in chap. V. under the name of *nitrous*, are often produced, and which injure the purity of the factitious air. This method of obtaining pure air ſeems alſo to be preferable to thoſe in which the air is expelled from red lead and other ſubſtances merely by heat, becauſe theſe ſubſtances muſt be put into a gun-barrel, or other metallic veſſel; and it is known that metals expoſed to heat phlogiſticate air, and ſometimes emit a noxious inflammable gas. And when we conſider that this pure factitious air, by whatever means it is obtained, is capable of producing five or ſix times the effect of atmoſpherical air in every inſtance in which air is known to exert its peculiar properties, it cannot be doubted, that the breathing of this air, during ſome longer or ſhorter time, muſt produce ſenſible effects in the animal economy. The inveſtigation of theſe effects ſeems to be worthy of the attention of phyſicians.

*magnesia alba*, *wood ashes*, *flints*, and *Muscovy talc*, as Dr. *Priestley* has very happily discovered. *Vol. II. p.* 69, &c. He moistened any of the above-mentioned earthy substances with spirit of nitre, and put the substance thus moistened into a gun-barrel, or into a phial, into the neck of which was ground a bent glass tube. *See Plate, fig.* 1. C D B. He immersed the nose of the gun-barrel or of the glass tube into water, and placed over it an inverted jar filled with water. Upon applying heat to the part of the gun-barrel which contained the mixture, or to the bottom of the phial, an elastic fluid was expelled from the mixture and it passed into the inverted jar. By changing the jar frequently, he was able to examine the fluid expelled at different periods of the process. Thus he obtained from mixtures of each of the above-mentioned earthy substances with nitrous acid, considerable quantities of air, some part of which he found to be very pure, and other parts to be mixed with calcareous and with nitrous gas, described in *chap. III.* and *V.* In the further prosecution of his experiments he obtained this pure air, not only by moistening minium and flowers of zinc with nitrous acid, but also by treating all other *metallic earths* in the same manner; and he observed, that while these metallic and earthy matters contained any phlogiston, the gas obtained was chiefly nitrous; but that by continuing or repeating the process with more spirit of nitre, after the phlogistic matter had been expelled, pure air was copiously produced. The metals themselves, treated with nitrous acid, yielded, during their solution, nitrous gas, and afterwards pure air. When chalk, magnesia alba, wood ashes, or any of those substances are used, which contain calcareous gas, this gas must be previ-

previouſly expelled by the acid. And when any earth has been dephlogiſticated and deprived of its gas, it may be uſed repeatedly, as long as it laſts, for the production of this air, by moiſtening it again and again with nitrous acid.

The *denſity* of this pure air was found by Dr. *Prieſtley* to be to that of atmoſpherical air, as 187 to 165. *Vol. II.* 94.

29. Pure air may be obtained from *nitre* alone by expoſing it to violent heat in a gun-barrel. *Exper. and Obſer. Vol. I.* 155.

30. A conſiderable quantity of pure air is extricated in the proceſs for diſtilling acid of nitre from a mixture of nitre and vitriolic acid, or from a mixture of nitre and calcined martial vitriol. Theſe operations muſt be performed in glaſs veſſels, for if iron veſſels are uſed, as is done by the diſtillers of aqua-fortis, nitrous gas is chiefly produced. From an ounce of pure nitre mixed with half an ounce of pure concentrated vitriolic acid, expoſed to heat in glaſs veſſels, I obtained, beſides the uſual quantity of nitrous acid, thirty ounce meaſures of pure air, after making proper allowances for the air previouſly contained in the apparatus. It did not appear that this air was mixed with either nitrous or calcareous gas.

From one ounce of nitre mixed with one ounce of calcined martial vitriol, I obtained 21 ounce meaſures of pure air, beſides the uſual quantity of nitrous acid.

But in the proceſs for obtaining by diſtillation nitrous acid, with arſenic, according to *Stahl*'s method, the whole quantity of the elaſtic fluid produced was nitrous gas. From one ounce of nitre mixed with 15 pennyweights of arſenic, I obtained, beſides the nitrous acid, ſixty ounce meaſures of nitrous gas.

31. Pure

31. Pure factitious air is obtained not only from the nitrous acid mixed with earthy and metallic substances, but also from compounds containing the *vitriolic acid.* Dr. *Priestley* obtained air from *alum* exposed to heat in a gun-barrel. *(See Vol. I. p.* 155. And *Signor Landriani* has lately discovered that pure factitious air may be obtained by applying heat to *turbith mineral*, as Dr. *Priestley* has acquainted me. This experiment Dr. *Priestley* has not only verified, but he has also found that pure air may be obtained from other combinations of vitriolic acid with metallic substances, as from *vitriols* of *iron*, *copper*, and *zinc.*

32. Several *mineral substances* contain pure air, as Dr. *Priestley* has lately discovered. Among these substances are *Lapis calaminaris*, *Manganese*, and *Wolfram.* The relation of these discoveries cannot fail of making an interesting part in his fourth volume of *experiments and observations.* That a small quantity of air may be obtained from *sedative salt*, he has mentioned in *Vol. II. p.* 86.

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## CHAP. III.

### *Of calcareous Gas.*

33. FROM various substances hereafter mentioned a permanently elastic fluid may be obtained, whose distinguishing property is, that it is capable of uniting with the caustic calcareous earth or quicklime dissolved in water, and of precipitating this earth from the water. Accordingly when a sufficient quantity of it comes in contact with lime-water, the water is rendered of an opake white colour, and the small particles of earth which produce this turbid

turbid appearance, gradually ſink to the bottom of the veſſel, leaving the water clear, and free from the earth which had been diſſolved in it; while the earth thus ſeparated from the water which had diſſolved it, is found to have recovered its ſolid form, and remains united and combined with the gas. Whatever gas therefore is obſerved to have this property of combining with the calcareous earth diſſolved in water, may be diſtinguiſhed from other elaſtic fluids by the name of *calcareous Gas*. Dr. *Hales* and his ſucceſſors have denominated this fluid, *fixed Air*; the impropriety of which term appears from conſidering, firſt, that this fluid is *fixed* only when it is combined with the calcareous earth or other ſubſtance; and that it is the reverſe of being fixed, that is to ſay, it is permanently elaſtic, whenever it is diſengaged; and ſecondly, that it does not poſſeſs the diſtinguiſhing properties of the fluid to which the word *air* has been immemorially aſſigned. Mr. *Bergman* of *Upſal* has given to this fluid the appellation of *Aerial acid*, which ſeems to imply that it is the acid conſtituent part of air, which doctrine has not been proved. It is called the *Mephitic acid*, by Mr. *Bewley*; and the *Mephytic gas* by Mr. *Macquer*, who at the ſame time acknowledges that this name is not ſufficiently characteriſtic. Neither of theſe appellations diſtinguiſh it from other gaſes, all which (excepting air) are mephytic or noxious to breathing animals, and ſeveral of which are equally or better entitled to the epithet *acid*, as *vitriolic acid gas*, *marine acid gas*, &c.

34. Calcareous gas may be obtained from a great variety of ſubſtances and by different proceſſes.

It may be extricated by *heat*, or by *acids* from all thoſe earths that are called *calcareous*, that is, all

thoſe

thoſe which by calcination may be converted into quicklime; ſuch as *chalk*, *marble*, *lime-ſtone*, and *marine ſhells*; likewiſe from *fixed* and *volatile alkalies*; and from *magneſia alba*. Thus, if any of theſe ſubſtances be expoſed to violent heat in a diſtilling apparatus of earthen or iron veſſels, the gas that is extricated may be collected; or if acids be added to any of them, an effervescence immediately ariſes, which effervescence proceeds from a number of ſmall bubbles of this gas that are expelled from theſe ſubſtances during their ſolution by the acids. If this effervescence be made in the apparatus repreſented in Fig. 1. C or E, the gas will paſs into and be collected in the jars B or F.

The *quantity* of gas obtained from the above ſubſtances was found to be as follow:

108 grains of *crabs eyes* diſſolved in one ounce and a half of diſtilled vinegar produced in vacuo 81 cubic inches of gas. *Boerhaave.*

One dram of *chalk* diſſolved in two ounces of diſtilled vinegar produced 151 inches of gas in vacuo. *Boerhaave.*

Two drams of *crabs eyes* with one ounce of vinegar produced 12 cubic inches of gas. *Eller*, *Berlin Mem.*

Two drams of *crabs eyes* with one ounce of ſpirit of ſalt produced 75 cubic inches of gas. *Eller.*

Two drams of *red coral* with one ounce of ſpirit of ſalt produced 52 cubic inches of gas. *Eller.*

*Magneſia* contains half its weight of gas. *Black*, *Edinburgh Eſſays.*

Marble contains $\frac{407}{1000}$ parts of its weight of gas. *Cavendiſh*, *Phil. Tranſ.* 1776.

*Lime-ſtone* contains $\frac{13}{32}$ of its weight of gas, and $\frac{2}{32}$ of water. *Jacquin*, *Examen Doctrinæ Meyerianæ.*

*Cremor calcis* contains $\frac{13}{32}$ of its weight of gas. *Jacquin, ibid.* ‡

*Chalk* dried with the heat of boiling mercury contains $\frac{443}{1404}$ of its weight of gas. *Lavoisier, Opusc. Phys. tom. 1.*

One dram of *salt of tartar* with half an ounce of spirit of nitre yielded 48 cubic inches of gas. *Eller.*

*Crystals of salt of tartar* yielded $\frac{428}{1000}$ of their weight of gas. *Cavendish.*

*Crystals of soda* yielded $\frac{576}{3615}$ of their weight of gas. *Lavoisier.*

*Volatile*

‡ The *cremor calcis*, or *cream of lime*, is the crust formed on the surface of lime-water exposed to the atmosphere, which crust falls to the bottom of the vessel, and a new crust is daily formed, till the whole of the quicklime dissolved in the water is precipitated. This crust is formed by the particles of calcareous gas which float in the atmosphere, uniting with the particles of quicklime at the surface of the lime-water. The earth thus combined with gas is restored to the same state in which it was before calcination, that is, of mild calcareous earth, which not being so soluble in water as quicklime is, crystallizes on the surface of the water; and this crystallized calcareous earth, or cream of lime, being heavier than the water, falls to the bottom; while new particles of the quicklime dissolved in the water, come into contact with the particles of gas floating in the atmosphere; and the process is repeated, till no more lime remains uncombined with gas in the water. But if the lime-water be exposed to evaporation, not only this mild calcareous crust will be formed in the manner above-mentioned, but also some of the quicklime, being deprived, by evaporation, of the water necessary to keep it dissolved, will be precipitated, and will mix with the cream of lime. Accordingly, M. *Bucquet* observed, that the powder precipitated from lime-water possessed the properties of quicklime. For when he distilled a mixture of this powder and sal ammoniac, he obtained *caustic* volatile alkali; whereas, if the powder had consisted entirely of the proper cream of lime, such as Mr. *Jacquin* had subjected to experiment, according to the above text, he would have obtained a mild volatile alkali.

*Volatile sal ammoniac* yielded $\frac{528}{1000}$ of its weight of gas. *Cavendish.*

*Volatile sal ammoniac* yielded $\frac{768}{1620}$ of its weight of gas. *Lavoisier.*

35. This gas escapes abundantly from the juices of *fruits*, infusion of *grains*, and of other *vegetable matters*, while they undergo the *vinous fermentation.*

The *quantity* of gas expelled from fermenting substances was first attempted to be ascertained by Dr. *Hales.* From 42 cubic inches of beer, 639 cubic inches of gas escaped in seven days; and from 26 cubic inches of bruised apples, 968 cubic inches of gas were produced in 13 days. (*Hales's Analysis.*) Mr. *Cavendish* found, that $\frac{57}{100}$ parts of dry sugar were converted into gas by the vinous fermentation; and that the quantity produced from the fermenting juice of apples was equal to $\frac{381}{1000}$ parts of the dried juice.

Dr. *Priestley* tried how much gas could be extracted from different kinds of wines. From one ounce and a half of each of the undermentioned wines, he obtained the following quantities of gas.

| | | |
|---|---|---|
| Madeira - - - - | $\frac{1}{100}$ | of an ounce measure. |
| Port, six years old - | $\frac{1}{48}$ | ditto. |
| Hock, five years old - | $\frac{1}{24}$ | ditto. |
| Barrelled claret - - | $\frac{1}{12}$ | ditto. |
| Tokay, 16 years old - | $\frac{1}{20}$ | ditto. |
| Champagne, two years old, | 2 | ditto. |
| Bottled Cyder, 12 years old, | $3\frac{1}{4}$ | ditto. |

*Experiments and Observations, II.* 227.

Much elastic fluid escapes from liquors undergoing the *acetous fermentation.* But whether this gas has

the properties of calcareous gas, cannot be ſaid with certainty, as they have not been hitherto examined.

36. Calcareous gas is expelled from *animal* and *vegetable ſubſtances* undergoing the *putrefactive fermentation.* (See Chapter XI.)

37. This gas may be extracted from *animal* and *vegetable* matters by means of *heat.* (See Chap. XII.)

38. This gas is found in *mines*, and other *ſubterraneous* places, (*ſee Chap. XIII.*) and in many *waters*, eſpecially thoſe called *mineral.* (See Chap. XIV.)

39. This gas may be expelled from ſeveral *mineral ſubſtances* by heat. Thus, M. *Krenger* obtained, by diſtilling a *greeniſh fuſible ſpar*, that was luminous in the dark, a gas which united with and cryſtallized a ſolution of fixed alkali, which effects are produced by calcareous gas, as will be ſhewn. Alſo, Mr. *Woulfe* expelled the ſame gas by adding vitriolic acid to *ſpathoſe white ore of iron*, to *Somerſetſhire manganeſe*, and to *Somerſetſhire white-lead ore.* (Philoſoph. Tranſact. vol. LXVI.)

40. Dr. *Prieſtley* has obtained this gas from ſeveral *ſaline* ſubſtances by means of heat, as from *green*, *blue* and *white vitriols*, *calcined alum*, *vitriolated tartar*, *borax*, and *white lead.* (Exper. and Obſerv. II. 112, &c.)

41. This gas is produced in the *revival of metallic calxes* by addition of *inflammable matter*, or by the *electric ſpark.* (Exper. and Obſerv. vol. II. 192.) From 144 grains of minium reduced by means of twelve grains of charcoal previouſly well burnt in a cloſe veſſel, M. *Lavoiſier* obtained, by expoſing the mixture to the focus of a lens, fourteen cubic inches of gas. (*Opuſc. Phyſ. I.* 258.)

42. This

42. This gas is produced during the *combustion* of every inflammable substance, excepting *sulphur* and *metals*. See §. 11.

43. This gas is produced by making *electric sparks* pass through air. For if this experiment be made in a glass tube, the mouth of which is inverted and immersed in lime-water, this liquor will be thereby rendered turbid. *Exper. and Observ. vol. I.* 186. *See also* §. 17. *n.*

44. Small portions of this gas are produced in the several *processes for obtaining factitious* air. *See* §. 26, 27, 28.

45. This gas is produced abundantly from *nitre* deflagrated with any animal or vegetable inflammable matter. From one pennyweight of nitre and a pennyweight of powdered charcoal, mixed well with two ounces of clean sand, to prevent the too hasty deflagration, and exposed to heat in the retort, (*Fig.* 1. E.) I obtained 16 ounce measures of calcareous gas.

46. The *specific gravity* of this gas was found by the Hon. Mr. *Cavendish*, to be to that of water as 1 to 511; or to that of air when this is 800 times lighter than water, as 157 to 100. According to Mr. *Lavoisier*, the specific gravity of this gas is to that of air as 561 to 455.

47. The *properties* of *calcareous earths* and of *alkalies are very much altered* by combination with this gas. For when *limestone* or other calcareous earths are, by calcination or otherwise, deprived of the gas usually combined with them in their natural state, they are thereby converted into *quicklime*. Also when *alkalies fixed* or *volatile* are deprived of their gas, by any means, they are thereby rendered more caustic, incapable of effervescing with acids and of crystallization, and

more powerfully ſolvent, as Dr. *Black* has proved by accurate and adequate experiments. *Edinb. Eſſays.*

The ſame excellent chemiſt has alſo ſhewn, that by recombining this gas with quicklime, magneſia, or alkalies, which had been previouſly deprived of it, their former weight and properties might be reſtored. From the greater acrimony communicated to quicklime and to alkalies, by depriving them of their contained gas, he has diſtinguiſhed them when thus deprived, or uncombined with gas, by the epithet *cauſtic*, as *cauſtic calcareous earth*, or *cauſtic fixed alkali*, or *cauſtic volatile alkali*; and when theſe earths or alkalies are combined with gas, he calls them *mild*.

Dr. *Black* contrived an apparatus, by which the gas extricated from an effervescing mixture could be conveyed into a cauſtic alkaline liquor, and ſhewed that by this method, the cauſtic alkali could be rendered mild, and could recover its effervescing and cryſtallizing properties. His apparatus conſiſted of two phials communicating by means of a bent tube, one end of which is inſerted into the mouth of one phial, and the other end into the mouth of the other phial. In one of the phials he put ſome cauſtic ſpirit of ſal ammoniac, and into the other phial he put ſome mild alkali or mild calcareous earth. Upon this mild alkali or earth he poured through a hole, purpoſely made in the ſide of the phial, ſome acid liquor, which immediately produced an effervescence as uſual, that is, it extricated from the alkali or earth their contained gas. The gas being thus diſengaged paſſed through the bent tube into the phial containing the ſpirit of ſal ammoniac, with which it combined, and which it changed from a cauſtic to a mild ſtate. For the ſpirit is by this proceſs rendered capable of effervescing with acids,

acids, and if it be much concentrated, it will be seen to crystallize during its impregnation with gas.

Dr. *Macbride* employed a similar apparatus to impregnate lime-water with gas, by which means he changed the caustic earth or quicklime which was dissolved in the water to a mild calcareous earth, which not being soluble in water as quicklime is, was therefore precipitated. *See Macbride on the dissolvent power of Quicklime.*

48. Dr. *Black* has further determined by experiments the relative powers of the several alkaline substances to unite with this elastic fluid, or the *affinities* of this fluid towards these substances. He found that this gas was more disposed to unite with *caustic calcareous earth* or *quicklime* than with any other substance; next with *fixed alkali*; then with *magnesia*, and lastly with *volatile alkali.*

Consequently mild volatile alkali may be deprived of its gas, or rendered caustic, by applying to it magnesia previously deprived of its gas, or caustic fixed alkali, or quicklime; and at the same time the magnesia, fixed alkali, or quicklime, are thereby rendered mild. Magnesia also may be deprived of its gas by means of caustic fixed alkali, or of quicklime; and lastly, mild fixed alkali may be rendered caustic by means of quicklime, which is at the same time rendered mild. Hence soap-boilers, in order to increase the activity or dissolving power of their alkali, boil it in water with quicklime.

According then to this doctrine, the *causticity* and other *peculiar properties* of *quicklime* and caustic *alkalies*, are the *original properties* of these substances, while they are *pure* and *uncombined*; and are not communicated to them by any supposed absorption of matter from

the fire in calcination, as *Meyer* and other chemists maintain *.

49. This gas is capable of adhering to, or combining with, *metallic precipitates.* Thus when a mild alkali or calcareous earth is added to a solution of a metal in an acid, the alkali or earth unites with the acid, the metal is precipitated, and the gas of the alkali or earth, which would have occasioned an effervescence if the acid had not been united with a metal, does not in this case produce any effervescence, but unites with, and increases the weight of, the metallic precipitate. Dr. *Black*, who first observed the union of this fluid with metallic precipitates, attributes the fulminating property of *aurum fulminans* to the gas which adheres to the gold precipitated by a mild alkali. The adhesion of gas to metallic precipitates, is confirmed by M. *Lavoisier.* The

* This theory, which has been ably investigated, has thrown much light on many chemical phenomena. But although it is well supported by the decisive experiments related by Dr. *Black*, (*Edinburgh Essays*,) it has nevertheless met with much opposition from some German and French chemists, who adopt the theory of M. *Meyer*, concerning the principle which he called *Acidum pingue*, of which an account is given in the Dictionary of Chemistry. *See* ACIDUM PINGUE. On the other side, Dr. *Black*'s doctrine has been ably supported and confirmed by M. *Jacquin*, in a treatise called *Examen chemicum Doctrinæ Meyerianæ de Acido pingui et Blackianæ de aere fixo.* And this treatise has been attacked by M. *Crantz*, in his *Rectificatio Examinis chemici Doctrinæ Meyerianæ*, &c.

As not only the reasonings but also the facts related by these authors were contradictory, M. *Lavoisier*, of the Academy of Sciences at Paris, undertook a series of Experiments, with a view of ascertaining the several questions in dispute; an account of which he has published under the title of *Opuscules physiques & chymiques, vol. I.* These experiments, which seem to have been made with accuracy and ability, can leave no doubt of the validity of Dr. *Black*'s experiments and deductions.

The precipitation of ſome metallic ſolutions ſeems therefore to be effected by what chemiſts call a double affinity; that is, the gas of the alkali unites with the precipitated metal, while the acid unites with the alkali. Accordingly, the precipitation of ſome of theſe metals requires that the precipitating alkali be mild, that is united with gas. Thus, ſilver diſſolved in nitrous acid cannot be precipitated by a cauſtic volatile alkali, although it may very perfectly by a mild volatile alkali.

This gas not only aſſiſts the precipitation of metals from their acid menſtruums, when it is combined with alkalies, but even ſometimes effects this precipitation, without the aid of an alkali. At leaſt, there is one inſtance of ſuch precipitation, when this gas is added to a ſolution of ſugar of lead, as Mr. *Hey* of *Leeds* has obſerved. *See Appendix to Dr. Prieſtley's firſt volume of Obſervations and Experiments.*

50. This gas is capable of being *abſorbed by water*, and the water thus impregnated precipitates the lime from lime-water, as Dr. *Macbride* has ſhewn.

The quantity of gas which water at the temperature of 55° of *Fahrenheit*'s ſcale can abſorb, was found by Mr. *Cavendiſh* to be more than equal to the bulk of the liquid, and to be greateſt when the water was cold, and compreſſed by an heavy atmoſphere.

The water thus impregnated acquires a *ſubacid taſte*, like that of the mineral waters called *acidulous*, and it alſo acquires a *greater denſity*; the ſpecific gravity of diſtilled water impregnated with gas being to that of diſtilled water not impregnated, as 1000322 to 1000000, according to an experiment made by M. *Lavoiſier*, *Opuſc. Phyſ. & Chym. tom. I. p.* 210.

Gas

Gas abſorbed by water may be thence expelled, by removing the preſſure of the atmoſphere from its ſurface by means of an air-pump; or by boiling the water, or by freezing the water. The greateſt part of the gas eſcapes merely by expoſure to the open air, eſpecially in warm weather.

51. This gas is alſo capable of being abſorbed by other liquors, as by *expreſſed oils* and by *ſpirit of wine*, which laſt liquor is found to be capable of abſorbing 2½ times its bulk of gas, when expoſed to 46° of heat, according to *Fahrenheit*'s ſcale. *Mr. Cavendiſh*, *Phil. Tranſ.* 1766.

52. This gas *extinguiſhes flame*; and even a mixture of nine parts of air with one part of this gas does not admit a candle to burn, as Mr. *Cavendiſh* has obſerved, *Phil. Tranſ.* 1766.

53. This gas when reſpired is *fatal to animals*. Dr. *Prieſtley* however remarks, that inſects and animals which breathe very little are ſtifled in this fluid, but are not ſoon killed; that butterflies and other flies generally become torpid and ſeemingly dead after being held a few minutes over a fermenting liquor; but revive on being brought into freſh air. *Exper. and Obſerv. vol. I. p.* 36. *Fiſhes* were killed by being put into water impregnated with this gas. *Id. vol. II. p.* 132. This gas is alſo fatal to *vegetable life*. Dr. *Prieſtley* obſerved that ſprigs of mint growing in water were frequently killed in a day, or leſs, by being placed over a fermenting liquor. *Vol. I. p.* 36.

54. This gas *reſiſts putrefaction*, as Dr. *Macbride* has proved from experiments. He ſhews, that by applying this gas to putrefying ſubſtances, their putrefaction is impeded; and he even pretends that they are hereby reſtored from a putreſcent to a ſound ſtate. He

He ſupports the opinion of Dr. *Hales*, that gas is the cementing principle of the particles of the ſolids and fluids in which it is contained, and that therefore when this is expelled, by fermentation, putrefaction, or otherwiſe, the coheſion of theſe particles muſt be diſſolved; and when it is reſtored, they may thereby recover their original conſtitution. But why is this gas conſidered as the cement or connective inſtrument more than any of the other principles which enter into the compoſition of theſe bodies? For by depriving a body of any of its conſtituent parts, the coheſion of the whole muſt be diſſolved, whether the principle thus taken away be gas, or earth, or acid, or alkali.

55. This gas when united with water is capable of *acting upon and diſſolving calcareous earth, magneſia, iron*, and perhaps ſome other metals. Mr. *Cavendiſh* firſt obſerved its property of diſſolving calcareous earths, and that although it at firſt precipitates the earth from lime-water, yet it afterwards re-diſſolves this earth. He has alſo ſhewn that the calcareous earth contained in *Rathbone-place* waters is kept diſſolved by no other menſtruum than this gas*. The ſame fluid is probably the ſolvent of the calcareous earth contained in all thoſe waters which depoſite their earthy ſediment upon expoſure to air.

Mr. *Lane* diſcovered that diſtilled water impregnated with the gas of fermenting or effervescing ſubſtances was capable of diſſolving iron, and that the water thus impregnated with the gas and iron had a vinous ſmell and taſte, like thoſe of ſome chalybeate waters, in many of which he thinks the iron is diſſolved merely by means of gas. Hence a mild and pleaſant chalybeate water may be made, by putting filings of iron in water impregnated with the gas obtained

* Phil. Tranſ. 1766, 1767.

from

from fermenting and effervescing substances. Not only iron in its metallic state, but also some of the *calciform ores of iron* may be dissolved in water impregnated with gas, as Mr. *Rouelle* found by experiment. *Lavoisier, Opuscules, I. p.* 156.

This gas occasions a *precipitation* in a solution of *sugar of lead*, as Mr. *Hey* of *Leeds* observes. (*Appendix to Dr. Priestley's first volume.*) This precipitate may be redissolved by adding nitrous acid.

56. The gas obtained from calcareous and alkaline substances, seems to suffer a decomposition when exposed to water. For, Mr. *Cavendish* observed, that some parts of it were much more easily absorbed than the rest; and that the residuum, which was about one fiftieth or one thirtieth part of the whole quantity, could not be more readily absorbed by water than air can. And Dr. *Priestley* found that the residuum which could not be absorbed by water had some of the properties of air, namely, that it effervesced with nitrous gas, (which is a test of air, as shall be hereafter shewn) and that it was not noxious to a mouse, although it was not so pure that a candle could burn in it. *See* §. 25, *and a note subjoined.*

57. Several circumstances concerning this gas lead to an opinion that it is of an *acid nature*, or that an acid enters into and predominates in its composition. Like other acids, it unites with alkalies, diminishes their causticity, and effects their crystallization. It dissolves calcareous earth and metallic substances, as iron and zinc. It has also been observed by Dr. *Bergman*, to alter the blue colour of the juice of tournesol to red. And lastly, it communicates an acidulous taste to water ‡. Calcareous

‡ M. *Macquer* is inclined to believe that several of the singular effects, commonly attributed to air, especially those on the colours of

Calcareous gas has been discovered to possess considerable *medicinal* powers. Concerning its effects in the *scurvy*, and other *putrid* diseases, the *phthisis pulmonalis*, *ulcers*, *cancers*, and the *stone in the bladder*, see several valuable papers in the appendix to Dr. *Priestley's Experiments and Observations*; the writings of Dr. *Macbride*, Dr. *Percival*, and other late medical authors.

57*. Among the many extraordinary discoveries that have been lately made concerning the permanently elastic fluids, is that of Mr. *Achard* of *Bale*, who is said to have made true *crystals*, as hard and of the same shape as the native rock-crystals, by applying calcareous gas in a certain manner, and by a very slow operation, to some earthy matter.

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## CHAP. IV.

### *On inflammable Gases.*

58. SOME gases are found to be capable of being inflamed. These are procured from very different matters, and by very different methods.

59. An inflammable gas is frequently found in *mines*, especially *coal-mines*, which sometimes takes fire, and explodes with great danger to the miners. *See Chap. XIII.*

60. Dr. *Hales* obtained an inflammable gas by distilling

o bodies, are caused by the calcareous gas, some portion of which, greater or smaller, is always mixed with the atmosphere. Such are, the blackness which black dyes acquire by exposure to air, the change of the green colour of a vat of indigo to a blue, the redness given to the liquor of the *murex*, the violet colour restored to the tincture of *orseille*, the weakening of many colours, bleaching, and other effects of exposing coloured bodies to the atmosphere. He thinks that light also may contribute to produce these singular effects. But he observes, that this subject is little understood, and he proposes to investigate it by further experiments.

ſtilling *wax*, *pitch*, *oyſter-ſhells*, *peaſe*, *amber*, and *coals*. *See Chap. XII.* Probably it might be obtained by applying heat ſuddenly to any *dry inflammable matter*, without excepting even the *inflammable* or *calcined metals*. Dr. *Prieſtley* procured inflammable gaſes from clean filings of *iron*, *zinc*, *braſs*, and *tin*, by expoſing theſe ſeparately to the focus of a burning lens in vacuo; and likewiſe from *iron filings* and *chalk*. *Vol. II. p.* 107, &c. But he could not procure any inflammable gas from *biſmuth*, *regulus of antimony*, *nickel*, *lead*, or *copper*; nor from *metallic calxes*.

61. An inflammable gas may be produced by diſſolving *iron*, *zinc* or *tin* in the *diluted vitriolic*, or *marine acids*.

According to experiments made by Mr. *Cavendiſh*, one ounce of zinc diſſolving in either of the above acids produced a quantity of inflammable gas equal in bulk to 356 ounces of water; one ounce of iron diſſolving in ſpirit of vitriol produced a quantity of gas equal in bulk to 412 ounces of water; and an ounce of tin produced as much gas as occupied the ſpace of 202 ounces of water. Dr. *Prieſtley* has produced an inflammable gas by diſſolving zinc and iron in radical vinegar; and by diſſolving copper, lead, and regulus of antimony in ſpirit of ſalt. *Vol. III. p.* 255, 256. The water over which this gas is contained becomes covered with a thin film, which is red, like ochre, if the gas has been procured from iron, and is white, if from zinc. *Vol. I.* 58.

62. *Marine acid gas*, (deſcribed in chap. VII.) or, the vapour of concentrated marine acid, may be *changed into an inflammable gas* by acting upon inflammable ſubſtances, as *ſpirit of wine*, *oil of olives*, *oil of turpentine*, *charcoal*, *phoſphorus*, *ſulphur*; and alſo upon *dry cork*,

*cork, oak, ivory, beef,* and even *flint.* (*Exp. and Observ. vol. I.* 149 *and* 232.) This marine acid gas being exposed to *quicklime* till $\frac{13}{14}$ were absorbed, the remainder was observed to be inflammable. *Id. vol. I. p.* 236.

63. An inflammable gas escapes from *putrefying animal or vegetable matters.* The waters of some *rivers* into which much fermentable matter is washed, as of the *Thames* and the *Aluta,* after having been confined during a certain time in casks, emit an inflammable gas. The surfaces of rivers are sometimes covered with an inflammable gas or vapour. *Exp. and Observ. vol. I. Appendix.* Inflammable vapours rise frequently from churchyards, houses of office, or from whatever places in which putrescent animal matters are collected.

Of the quantity of this gas which may be obtained from given quantities of putrefying matter, see Chap. XI.

64 An inflammable gas exhales from *liver of sulphur,* upon adding an acid, as *Meyer* and *Rouelle* have observed. (*Lavoisier, Opusc. Phys. tom. I.* 161.) The gas which is discharged from mixtures of sulphur with filings of iron, or zinc, is also found to be inflammable. *See Exp. and Observ. vol.* III. *p.* 259.

65. *Cygna* observes, that *air saturated with volatile alkali* is inflammable: and Dr. *Priestley* found, that *alkaline gas* was also inflammable.

66. Dr. *Priestley* observed, that the *electric spark* taken in oil, ether, spirit of wine, or spirit of sal ammoniac, produced an inflammable gas. *Exp. and Observ. vol.* I. 242. 245.

67. M. *de Lassone* has obtained inflammable gases by dissolving *zinc* and *iron* in *alkalies.* He discovered that liquid *volatile alkali* is capable of dissolving filings of *zinc,*

*zinc*, and that, during the solution (which requires very little heat) an inflammable gas, capable of fulminating, when mixed with air, is expelled from the mixture, and may be collected by means of a proper apparatus.

He has also obtained a similar gas from the solution of filings of zinc by *caustic fixed mineral alkali*, which was applied to the zinc in a liquid state, and was assisted by a boiling heat.

Filings of *iron*, although less soluble than those of zinc, by these alkalies, did nevertheless yield a gas no less inflammable and detonating than the preceding. M. *de Lassone* could not dissolve either of these metals by means of a mild fixed alkali. He observed however, during the boiling of this alkali in a liquid state with filings of these metals, that an elastic fluid was produced, which was found (he says) to be common air.

The solution of zinc, and of its flowers, by mild volatile alkali, produced ammonical silky salts, from which M. *de Lassone* obtained, by means of heat, a gas which was not inflammable, but possessed the properties of calcareous gas.

68. As *ether* has the singular property of mixing with any permanently elastic fluid, and expanding along with it; if therefore air be saturated with ether, an inflammable gas will be thereby formed. The essential oil or spiritus rector of *fraxinella* seems to have a similar property of forming an inflammable compound, by mixing with air. For when this plant is in flower, the vapour which exhales from it may be kindled by a lighted candle.

69. Dr. *Priestley* has shewn, that an inflammable gas, which burns with a blue flame, may be obtained from

from the nitrous acid, acting upon *spirit of wine* or other inflammable substances, and that this gas is produced (together with the nitrous gas described in chap. V.) during the action of that acid upon *metals*, especially upon *zinc* and *tin*. He observed this inflammable gas also in the distillation of a solution of zinc in nitrous acid, in the period between the production of phlogisticated, and that of the pure factitious air described in §. 28. *Experiments and Observations, vol. III. p.* 24.

70. An inflammable vapour or gas was produced by repeatedly distilling the same *nitrous acid* from *quicklime*. Pott *on the solution of quicklime by nitrous acid.*

71. The inflammability of this was observed to be *greatest*, when the *distillation* of inflammable matter was *hastily performed*, and with a *heat suddenly raised*; or when the *solution of metals* in acids proceeded with the *greatest vehemence*, as when heat was applied, and acids of a proper strength were employed; and when the *putrefaction* of animal and vegetable matters were *hastily excited*. Exp. and Obs. I. 58.

72. The *specific gravity* of inflammable gas was found by Mr. *Cavendish* to be eleven times less than that of common air, when this is 800 times lighter than water.

73. The *mixture of air* is necessary to the inflammation of this gas, as of other inflammable substances. Mr. *Cavendish* has made experiments to discover the effects of firing different proportions of air, and the inflammable gas described in §. 61; and he found the following results:

A mixture of nine parts of air with one part of inflammable gas, did not fire easily, and the inflammation was accompanied with little sound.

Two parts of inflammable gas, and eight parts of air, were easily fired, and the sound produced was moderately loud.

Three parts of inflammable gas, and seven parts of air, gave a very loud sound.

Four parts of inflammable gas, and six parts of air, gave a sound very little louder than the former mixture.

Equal parts of gas and air, sounded like the last mixture.

In the first experiment, when nine parts of air were mixed with one part of gas, the flame spread gradually through the bottle containing the mixture. In the three next experiments, no light could be perceived, perhaps, because the flame lasted too short a time to make a sufficient impression on the eye. When equal parts of the two fluids were employed, a light was seen.

A mixture of six parts of inflammable gas, and four parts of air, produced a sound which was not loud, and after the explosion it continued to burn a short time.

A mixture of seven parts of inflammable gas with three parts of air, gave a gentle bounce, and continued to burn some seconds.

A mixture of eight parts of inflammable gas with two parts of air, caught fire without noise, and continued to burn only in the neck of the bottle.

From these experiments Mr. *Cavendish* infers, that unless the mixture contain more air than inflammable gas, the air is not sufficient to consume the whole of the gas, and that the remainder burns by means of air rushing into the bottle after the explosion ‡.

74. The

‡ The phenomena accompanying the inflammation of inflammable gas are well exhibited in the following experiment, related by

74. The *nitrous acid* in this, as in other instances, seems to supply the place of air in assisting the inflammation of this gas. As appears from some curious experiments of Dr. *Priestley*. *Experiments and Observations*, *vol.* III. *p.* 260.

He filled jars with nitrous acid, and inverted the jars so that their mouths were immersed in the same acid; he then displaced this acid, by throwing inflammable gas into the inverted jars. The gas which



by Mr. *Warltire*. *Appendix to Dr. Priestley's Exper. and Observ. vol. III. p.* 367.

"I have several times repeated an experiment with inflammable "air, that appears to me very curious. I fit a glass tube into a "tapering cork, and that to a round-bottomed phial, in such a "manner that a bend in the tube, when hung over the side of a "tub, be almost two inches under the water, but that the end "may rise four inches higher than the bend. The phial being "charged with the proper materials for producing inflammable air "briskly, it must be lighted, as it discharges from the end of the "tube, and will continue a flame as long as any inflammable air "rises, provided care is taken to prevent any moisture ascending "along with the inflammable air. The phial and its tube being "placed on the edge of the tub, a receiver, such as for an air-"pump, is to be brought over the burning air, and its edge "sunk in the water upon the bend of the tube. The inflamma-"ble air continues to burn as long as there is common air in the "receiver capable of supporting the flame. The appearances in "this experiment are very remarkable. About as much inflam-"mable air vanishes as is equal to the bulk of the common air; "the burning is attended with much heat and light; the common "air is contracted full one fifth part of its original dimensions; im-"mediately after the flame is extinguished, there appears through "almost the whole of the receiver, a fine powdery substance like "a whitish cloud, and the air in the glass is left perfectly noxious. "The bent tube should be slipped from under the receiver, the "instant the flame goes out, to prevent the inflammable air mix-"ing with the other air in the receiver."

had thus past through nitrous acid, was found to be more or less inflammable, (without mixture of air) and capable of producing an explosion, more or less loud, in proportion to the strength of the acid. He observed, that this gas remained inflammable a short time only after it had past through the acid; probably because the acid vapour was gradually deposited; and also that the gas lost its property of inflammability without mixture of air, by making it pass through water, in which case, the acid vapour is probably separated from the gas, by means of the water. *Experiments and Observations on Air, vol. III. p.* 260. *and vol. I. p.* 65.

75. The inflammable gases, which have been principally observed, *explode* during their inflammation, yet many others burn very well without explosion. Such are the inflammable gases extricated from a mixture of calx of zinc and charcoal, and from Prussian blue, by exposing these substances to heat in a gun-barrel, as M. *de Lassone* has observed. The detonation of inflammable gases may be prevented, as M. *de Lassone* affirms, by mixing them with nitrous gas: and Dr. *Priestley* observes, that if inflammable gas be mixed with nitrous gas, the mixture burns with a green flame. *Exp. and Observ. I.* 117.

75.* Inflammable gas may be kindled by the *electric spark*, even when the electricity is not very strong, as *Signor Alexander Volta* has observed. *Exp. and Observ. vol.* III. *Appendix.* M. *Chaussier* also shews, that inflammable gas may be kindled by electric sparks. For this purpose he filled a bladder with this gas, and made it pass from thence into the open air through a tube, at the extremity of which was a hollow copper ball pierced with one or more holes, through which the

the gas issued. By directing the spark to one or more of the holes, the gas, which mixed with air as soon as it issued, was immediately kindled, and continued to burn as long as the inflammable gas was pressed out of the bladder. When the ball had only one hole, there was a stream of flame, like that of an enameller's lamp, by means of which M. *Chaussier* melted metals, and revived metallic calxes without addition, the phlogiston of the gas serving for the purpose of reduction: and he pretends, that metals may be melted with less heat, and in less time, by means of this flame, than of common fire. When a tapering hollow tube was substituted to the ball, so that the gas was made to issue through a small hole in the point of this tube, no inflammation could be made to take place by applying electric sparks, although the point was thereby rendered luminous. *Rozier's Journal, October* 1777.

Signor *Volta* thinks that the *ignes fatui*, which he supposes to be inflammable gas that has arisen from marshy grounds, and also that the *falling stars* may have been kindled by means of electricity.

75.** Messrs. *Macquer* and *De Montigny* have observed, that pure inflammable gas obtained from zinc and iron dissolving in vitriolic acid, being applied to solutions of silver, mercury, lead, and other metals, communicated immediately to these solutions, the brown or black colour, which indicates the union of phlogiston with metallic earths, and an approximation to reduction.

These chemists have not ascertained what change is produced upon the inflammable gas by this species of decomposition, but they mean to investigate this matter by further experiments. *Diction. de Chymie. Gas inflammable.*

76. Mr. *Cavendish* did *not* find that this gas was *absorbed by the water*, over the surface of which it stood: and it certainly may remain thus long without any considerable diminution. But Dr. *Priestley* says, that by agitation in boiled water, no less than three fourths of this gas may be absorbed, and that the remainder was but weakly inflammable. *Vol. I. p.* 67. And the inflammable gas, thus diminished by agitation in water, was found to have so far acquired the properties of air, that when it was mixed with nitrous gas, a considerable diminution was observed. *Id. vol. I.* 188.

77. Inflammable gas is *not diminished* by fumes of *liver of sulphur*, or by the *electric spark*. Neither did the electric spark passing through this gas change the colour of a solution of archil in water. *Exper. and Observ. vol. I.* 247. The effects of exposing this gas to *oil of turpentine* were remarkable. Its bulk was thereby considerably enlarged; it was rendered less inflammable; and it was made capable of diminishing nitrous gas nearly as much as air is. *Id. vol. III. p.* 366.

78. Inflammable gas is *noxious to animals*; but it does *not* seem to be *hurtful to vegetable life*; for Dr. *Priestley* found that plants grew pretty well several months in it, and that it still continued inflammable. *Vol. I.* 61.

CHAP.

## CHAP. V.

### *On nitrous Gas.*

79. DR. *Hales* obſerved, that when a mixture of nitrous acid with a martial pyrites was diſtilled; or when the nitrous acid was poured upon antimony, or mercury, or filings of ſteel, a gas was produced, which readily *united with air*, and produced *heat* by their union, while the mixture became *red* and *turbid*, and its quantity or *bulk* was found to be conſiderably *leſs* than the ſum of the quantities of the two fluids employed. *Statical Eſſays, vol. I.* 224. *and vol. II.* 280. Notwithſtanding theſe ſingular appearances, no further notice was taken of this gas, till Dr. *Prieſtley* thought it a ſubject worthy of his inveſtigation; and how ſucceſsfully he has proſecuted his inquiry, the following part of this chapter will evince. To this fluid he has given the name of *nitrous Air.*

80. Dr. *Prieſtley* has procured the ſame gas, by diſſolving in the nitrous acid any of the following metals, *iron*, *copper*, *mercury*, *ſilver*, *biſmuth*, and *nickel*, and alſo by diſſolving *gold* or *regulus of antimony* in aqua regia. He obtained little or no gas by diſſolving *lead* in nitrous acid; and he found that the gas produced by diſſolving *zinc* and *tin* in that acid, had the properties of the nitrous gas in a ſmall degree only. *Exper. and Obſerv. vol. I. p.* 110 *and* 126. *and vol. III. p.* 17. M. *de Laſſone* ſays, that the gas which he obtained, by diſſolving zinc in nitrous acid, was not *nitrous*, but *calcareous gas.*

81. Dr. *Prieſtley* has obtained this gas, by applying nitrous acid to almoſt all kinds of inflammable ſub-

ſtances, and more eſpecially to *vegetable* than to *animal* matters. Both theſe matters, thus treated with nitrous acid, yielded alſo conſiderable quantities of calcareous gas; but this difference was remarked between them, that vegetable matters yielded a much larger quantity of nitrous gas, and that the gas obtained from animal matters contained alſo a portion of a gas which is ſimilar in its properties to air in which candles had burnt till they became extinct, and which he therefore calls *phlogiſticated air*. This ſeems to eſtabliſh a new diſtinction between the animal and vegetable kingdoms. *Exp. and Obſerv. vol. II. p.* 145.

82. A large quantity of elaſtic fluid is expelled in the proceſs for making *nitrous ether* by diſtillation; and the *Duc d'Ayen* has found, that this fluid conſiſted of nitrous gas mixed with *ether*, which has the ſingular property of expanding into an elaſtic fluid when mixed with any kind of gas, as Dr. *Prieſtley* has obſerved. *Id. vol. I. p.* 252.

83. The ſingular phenomena which accompany the mixture of this gas with air have been mentioned in §. 79, namely, the *heat*, *redneſs*, *turbid appearance*, and *diminution of bulk*.

Dr. *Prieſtley* obſerves, that the diminution of a mixture of this gas and of common air is not an equal diminution of both the kinds, but (ſays he) "of about "one fifth of the common air and as much of the *ni*-"*trous air* as is neceſſary to produce that effect; which, "as I have found by many trials, is about one third "as much as the original quantity of common air. "For if one meaſure of nitrous air be put to two mea-"ſures of common air, in a few minutes (by which "time the effervescence will be over, and the mixture "will have recovered its tranſparency) there will want

"about

"about one ninth of the original two meaſures; and "if both the kinds of air be very pure, the diminu- "tion will go on very ſlowly, till, in a day or two, "there will remain one fifth leſs than the original "quantity of common air." *Exp. and Obſerv. vol. I. p.* 110.*

When air is once ſaturated with the nitrous gas, any further addition of gas occaſions an equal encreaſe of the bulk of the mixture, and produces no heat or redneſs.

The nitrous gas ſuffers no diminution upon being mixed with any other kind of gas than air, and conſequently the diminution is greater when the air is purer, as Dr. *Prieſtley* has obſerved. And he has accordingly very happily applied this nitrous gas, as a teſt, to *diſtinguiſh* air from other kinds of gas, and to *meaſure the purity of air*; by which means we are furniſhed with a new method of examining air, and conſequently of extending our knowledge of the atmoſpherical fluid.

In order to examine or aſcertain the purity of any kind of air, let a jar Y *(ſee Plate and explanation)* be filled with water, and inverted into a veſſel of water. Into this jar pour two meaſures of the air to be tried, and one meaſure of nitrous gas. If, when the effervescence is over, and the mixture has loſt its turbid appearance, the quantity remaining be only one meaſure and ſeven ninths of a meaſure, we may know that the air is as pure at leaſt, as the air appeared to be in

* M. *Lavoiſier* concludes from his experiments, that the proportion of air and nitrous gas requiſite to produce a ſaturation, is 16 parts of the former to 7½ parts of the latter; and that, when this proportion is obſerved, the whole quantity of nitrous gas diſappears, and alſo one fourth of the air employed.

in the trials made by Dr. *Priestley*, from which he deduced the rule above quoted. If the quantity of the remaining mixture be greater than $1\frac{7}{9}$ measures, then the air is known to be proportionably less pure. But if, upon adding another measure of nitrous gas, a further diminution takes place, that is, if the quantity of the remaining mixture be less than $2\frac{7}{9}$ measures, the air will be known to be purer in proportion to the further diminution that may be produced by adding more nitrous gas. Accordingly, when pure factitious air (§. 26, 27, 28.) is subjected to this mode of trial, four, five, or even six times the above-mentioned quantity of nitrous gas may be added to this pure air, before any augmentation happens of the bulk of the air employed.

This mode of trial may be applied to discover the state and salubrity of air in different places and in different times. *Exper. and Observat. vol. I. p.* 116. Accordingly *Signor Landriani*, in a tour he lately made through *Italy*, examined, by this method, the state of the air, with regard to its purity, in the different places through which he passed, and he found that the result of his experiments corresponded exactly with the opinion which generally prevailed among the inhabitants concerning the salubrity of the air. In the mountains near *Pisa*, he found that the air was more and more pure, as he ascended higher; and that at *Mount Vesuvius*, the air was more vitiated, as it approached the summit. The air of the *Pontine lakes*, that of the *Scirocco* at *Rome*, that of the *Campagna Romana*, of the *Grotta dei Cani*, of the *Solfatara* at *Naples*, of the Baths of Nero at *Baia*, of the sea-coast of *Tuscany*, were all found, on examination, to be such as daily experience had led him to expect.

84. This

84. This gas *extinguishes flame*, (Hales, Appendix) and it is *noxious to animals*. But frogs and snails were observed to live in it a considerable time, although they at length died in it. *Exper. and Observ. vol. I. p.* 119. 226.

85. This gas is capable of being *absorbed* by various *liquors*, and in various proportions.

Distilled *water absorbs* about one tenth of its bulk of this gas; and the water thereby acquires an acid taste, and becomes covered with a film. Nitrous gas* was by long *agitation* in water rendered capable of being *diminished by fresh nitrous gas*, as air is; and when by this agitation it was reduced to one eighteenth of its original bulk, a mouse could live in it. *Exp. and Observ. I.* 189. 120.

Nitrous gas was very suddenly and copiously *absorbed* by *spirit of nitre*; the colour of which was thereby changed first to a deep orange, then to a green. The quantity of gas absorbed by a strong spirit of nitre was in bulk 650 times greater than the quantity of spirit employed. Towards the end of the process, the evaporation of the acid spirit was observed to be so very great, that, at last, only half the quantity of spirit remained, and this was further observed to be very weak. The absorption of the gas seems to have rendered the spirit very volatile. *Exper. and Observ. vol. III.* 122, &c.

*Oil*

* Mr. *Bewly* remarks, that this gas does not give to water a sensible acid impregnation, unless it comes into contact, or is mixed with a portion of air. *Exper. and Observ. I.* 318. Neither does it seem to possess any of the properties of acids, while it retains its elastic state. The *Duke de Chaulnes* introduced some tincture of tournesol into a vessel containing nitrous gas, and observed, that no alteration was produced in the colour of the liquor.

*Oil of vitriol* was obſerved to abſorb about as much of this gas as water does; and to be thereby rendered of a purple colour. *Id.* III. 129.

*Spirit of ſalt* imbibed one twentieth of its bulk of this gas, and its colour was thereby changed from yellow to a ſky-blue. *Id.* III. 129.

This gas was alſo abſorbed by concentrated *vegetable acids*. Id. III. 130.

Nitrous gas has been obſerved by Dr. *Prieſtley* to be capable of being abſorbed by *oils*, *ether*, *ſpirit of wine*, and by *cauſtic alkali*. The quantity abſorbed by oil of turpentine was conſiderable, being equal in bulk to eleven times the quantity of oil employed. The whole of a given quantity of gas however could not be thus abſorbed; for a reſiduum, which extinguiſhed a candle and ſeemed to be like air which had been expoſed to burning ſubſtances, remained equal to one fourth of the quantity of gas expoſed to the oil of turpentine. *Exper. and Obſerv. vol. III. p.* 112, &c.

86. Nitrous gas being expoſed to a large ſurface of *iron* during two months, was rendered *capable of maintaining flame*, and even enlarging the flame, although it continued highly noxious. The ſame effects were produced by expoſing nitrous gas to *liver of ſulphur*, during twenty-four hours; (*Exper. and Obſerv. I.* 216, 217. *II.* 178.) and to a mixture of filings of iron and ſulphur. *Id. III.* 141.

A gas, poſſeſſed of this inflammable property, may be procured by diſſolving tin or zinc in nitrous acid. It may alſo be obtained by applying heat to a ſolution of iron in that acid, after the common nitrous gas had eſcaped from it during the ſolution, without heat. *Id. III.* 133, &c.

Nitrous

Nitrous gas was diminiſhed, by expoſure to *iron-filings and ſulphur* made into a paſte with water, to one fourth of its original dimenſions. When it has been thus diminiſhed by iron-filings and ſulphur, the reſiduum cannot be diminiſhed by air, nor by agitation in water. *Id.* I. 223.

87. The *electric ſpark* taken in nitrous gas diminiſhed this gas to about one fourth of its original quantity, and rendered it unfit for diminiſhing air. When this ſpark was taken while the gas was in contact with a ſolution of archil in water, the colour of this ſolution was changed from blue to red, in a very great degree. *Exper. and Obſerv. vol.* I. 122. II. 238.

88. Nitrous gas is quickly decompoſed by a ſolution of *green vitriol* in water; the colour of which is thereby rendered darker, but is reſtored to green, on expoſing the ſolution to air. *Exper. and Obſerv.* III. *Preface, p.* 33.

89. The *denſity* of nitrous gas appeared by an experiment of Dr. *Prieſtley* to be to that of air, as 184 to 185. *Exper. and Obſerv. vol.* II. *p.* 94.

90. Dr. *Prieſtley* thinks that this gas conſiſts of the vapour of the nitrous acid united with phlogiſton, together perhaps with ſome ſmall portion of metallic calx. *Exper. and Obſerv. vol.* I. *p.* 271.

And Mr. *Bewley* juſtly remarks, that this nitrous acid in form of a fluid, not condenſable by cold, cannot be reſtored to a liquid ſtate without the preſence and admixture of air. *Exper. and Obſerv.* I. *Append.* 318.

The red appearance therefore which takes place upon mixing nitrous gas with air, ſeems to proceed from the many ſmall particles or minute drops of nitrous acid juſt reduced from an elaſtic ſtate to that

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of a liquid, in consequence of the mixture of this gas with air; and these particles gradually subside, or are absorbed by the water, and disappear.

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## CHAP. VI.

### *On vitriolic acid Gas.*

91. THE *vitriolic acid* is capable of being raised by means of heat, and of mixture with *oils*, *charcoal*, or other *inflammable substance*, into an elastic fluid, which is not condensable by cold, as Dr. *Priestley* has discovered. *Exper. and Observ. vol. II. p.* 7. This elastic fluid is called by Dr. *Priestley*, who first observed it, *Vitriolic acid air.*

92. This gas is very readily *absorbed by water*; when thus brought into the form of a liquid, it possesses all the properties of the vitriolic, or rather perhaps of the volatile vitriolic or sulphureous acid. As this gas so readily unites with water, it therefore cannot be collected in vessels filled with this liquid, but with some fluid on which it has no action, as mercury.

93. The same kind of gas may also be obtained by means of heat from concentrated vitriolic acid and several *metallic substances*, as copper, silver, lead, iron and zinc. It has been already observed, that a gas of a different kind may be obtained from the same acid in a dilute state acting upon some of these metals. *See Chap. IV. on inflammable gas.*

94. The following *properties* of this gas were observed by Dr. *Priestley*. Exper. and Observ. vol. II. p. 7, &c.

*a.* It was *heavier than air.*

*b.* It *extinguished flame.*

*c.* It

*c.* It was *absorbed by charcoal*, to which it communicated a very pungent smell.

*d.* It *dissolved camphor* readily, and reduced it to a transparent liquor, from which, by addition of water, camphor was reproduced.

*e.* It did *not act* upon iron, nitre, common salt, or sal ammoniac.

*f.* It formed a *white cloud* upon being mixed with a vapour of *volatile alkali.*

*g.* It *injured common air.*

*h.* When *electric sparks* were passed through this gas, included by means of quicksilver, in a glass tube, the sides of the tube became tinged with a black stain *.

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## CHAP. VII.

### *On marine acid Gas.*

95. CHEMISTS have remarked, that a considerable quantity of elastic fluid is disengaged during the distillation of spirit of salt by means of oil of vitriol, by which means much of the strongest acid escapes; and Mr. *Woulfe*, (Phil. Trans. vol. LVII.) in order to prevent this loss, has invented an apparatus, by means of which the vapour is made to pass repeatedly through water, and is thereby condensed; but this fluid was considered as a mere vapour, condensable by cold. Mr. *Cavendish* however, in attempting to produce an inflammable gas from marine acid acting on copper, in the same manner as he had done from

* The same stain is produced when the electric spark, and more effectually when the electric shock is made to pass through common air confined by quicksilver. This black matter, when heated, appears to be pure quicksilver. *Exp. and Obser. vol. III. Pref. p.* 34.

from that acid acting on iron and zinc, found that an inflammable gas could not be thus obtained; but from the phenomena accompanying the experiment was led to think, that some elastic fluid had been formed in the operation, and had been condensed as soon as it had come into contact with water. *Phil. Trans. vol. LVI.* This appearance of an elastic fluid that was condensed by contact with water, seemed to Dr. *Priestley* to be an object worthy of investigation, and from the experiments which he made with this view, he discovered a new species of gases; namely, that to which the epithet *acid* is given. He discovered that a gas could be obtained not only from spirit of salt acting upon copper, but also from that acid alone by means of heat; that this gas was quickly absorbed by water, but when collected in jars previously filled with quicksilver, that it retained its elasticity, and was therefore, according to our definition, a true permanent gas; to which he gave the appellation of *marine acid air.* Exper. and Observ. vol. I. p. 143.

96. The water which has absorbed this gas, becomes a *spirit of salt*, more or less strong in proportion to the quantity of gas absorbed, and thus a stronger marine acid spirit may be obtained than by any other method. *Exper. and Observ. vol. I. p.* 148. *Ice* is as quickly dissolved by this acid gas, as it is by a hot fire. *Id. vol. I. p.* 240.

97. This gas *acts upon* many *metallic* and *inflammable substances*, and is thereby changed into an *inflammable gas*, as is shewn in chap. IV. §. 62. But the fumes of *liver of sulphur* did not render it inflammable: these fumes reduced its dimensions to one half. *Exper. and Observ. vol. I. p.* 235.

Marine

Marine acid gas was a little diminiſhed by the *electric ſpark* paſſing through it. *Exp. and Obſerv. vol. II. p.* 239.

98. This gas *extinguiſhes flame*; and when mixed with air, it gives to flame a beautiful green or bluiſh colour. *Id. I.* 147.

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## CHAP. VIII.

### *On nitrous acid Gas.*

99. NOT only the nitrous gas above deſcribed (chap. V.) may be obtained from the nitrous acid; but alſo the mere vapour of heated ſpirit of nitre was diſcovered by Dr. *Prieſtley* to aſſume the form of gas: at leaſt, it remained uncondenſed by the cold of the atmoſphere to which it was expoſed. *Exper. and Obſerv. vol. II. p.* 169.

The difficulty of finding a fluid capable of confining this vapour, and on which it has no action, prevented a complete inveſtigation of it: for it was readily abſorbed by water, and it diſſolved quickſilver. Our knowledge of it is therefore very imperfect; but if it ſhould be found, upon further examination, to be a permanent gas, it may be denominated *nitrous acid gas*; while the gas deſcribed in chap. V. may retain the name of *nitrous gas.*

When this vapour was mixed with nitrous gas, the mixture became red and turbid, the nitrous gas was diminiſhed, and its power of diminiſhing air was leſſened. *Exper. and Obſerv.* II. 170.

Dr. *Prieſtley*, to whom we are indebted for every thing we know concerning this gas, not finding any vapour in the ſtate of liquor capable of containing it,

made it pafs from the veffel containing nitrous acid acting upon metals, into phials containing air, by which means the phials were filled with this vapour mixed with air. The vapour in thefe phials was obferved to be red; and the intenfity of the red colour of this vapour, and alfo of the high-coloured fpirit of nitre itfelf, was encreafed by heat. This phenomenon Dr. *Priefley* attributes to the action of heat on the phlogifton contained in the vapour and acid.

This vapour being mixed with air, and afterwards feparated from the air by being abforbed by water, was found to have fo altered the air, that it was no longer capable of diminifhing nitrous gas. *Exp. and Obferv. vol.* III. *p.* 192.

Water very readily abforbs this vapour, and is thereby converted into a fpirit of nitre, the colour of which varied according to the ftrength of the impregnation, from blue to green, and thence to a yellowifh hue. *Id.* III. 198.

During the beginning of the impregnation of the water with this nitrous acid vapour, the water was obferved to fparkle much; and the impregnated water gradually emitted fo much elaftic fluid during two or three days after the impregnation, that the veffels, if clofely ftopt, were in danger of burfting. This elaftic fluid was expelled more copiouffly by heat; and upon examination, was found to be *nitrous gas*. The quantity of this gas which was expelled from impregnated water, was in bulk ten times greater than the water employed. But it appears from Dr. *Priefley*'s former experiments, that water can abforb only one tenth of its bulk of nitrous gas; therefore this large quantity of nitrous gas does not enter as nitrous gas mixed with the acid vapour into the water; but

feems

ſeems to be formed by the union of the vapour with the water.

This acid vapour, united with expreſſed oils, rendered them of blue and yellow colours, and coagulated them. By combining with eſſential oils, it produced heat and effervescence; and once an exploſion happened. *Exper. and Obſerv.* III. 208. 210.

The gas produced by the union of the vapour with oils, was found to be ſimilar in its properties to phlogiſticated air, or air which had been expoſed to burning or phlogiſtic bodies; that is, it extinguiſhed flame, and poſſeſſed none of the diſtinguiſhing properties of other gaſes. *Id.* III. 211.

Oil of vitriol and ſpirit of ſalt imbibed this acid vapour. The ſpirit of ſalt thus impregnated became an aqua regia, which readily diſſolved gold; and when heated, it yielded a conſiderable quantity of nitrous gas, in the ſame manner as the impregnated water was obſerved to do. But no gas could be expelled from the impregnated oil of vitriol. *Id.* 222.

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## CHAP. IX.

### *On fluor acid Gas:*

100. DR. *Prieſtley* has obtained an acid gas, by diſtilling the minerals called *fluors* with oil of vitriol, as in the proceſs for obtaining the acid of fluors. (*See Dictionary of Chemiſtry, article Fluors.*) And he has obſerved the following properties of this gas, to which he gives the name of *Fluor acid air.* Exp. and Obſerv. II. 187. and III. 285.

This acid vapour or gas no ſooner came into contact with water than part of it was abſorbed, and at the ſame time the ſurface of the water became covered with a *ſtoney film,* ſimilar to that produced by the

mixture of the acid of fluors with water, and which Mr. *Scheele* pretends to be a *quartz* or *flint*. When this film was broken, another crust was formed on the surface of the water, and so on successively till the whole of the gas was absorbed by the water, which thereby becomes impregnated with a very volatile acid. As this acid is so readily absorbed by water, it requires to be confined in quicksilver.

101. This gas retains its acid properties; for besides its uniting so readily with water, it forms a cloud with alkaline gas, described in chap. X. and it may be absorbed by chalk, from which it extricates calcareous gas.

102. This gas was *absorbed* by *charcoal*, by *rust of iron*, and by *alum*, the surface of which it rendered white and opake, by seizing the watery part of the alum. When *salt-petre* was exposed to it, the vessel became filled with red fumes, and the gas was gradually diminished till only one tenth part of it remained. One fourth part of this residuum was absorbed by lime-water, in which it occasioned a precipitation.

103. Water impregnated repeatedly with this acid gas, and freed from the earthy crust, being heated, was found to yield a gas which did not form any crust with water, but possessed all the properties which have been observed of vitriolic acid gas.

104. From the above properties of this fluor acid gas, Dr. *Priestley* is induced to think that the *fluor acid* is *not a particular acid*, but is the *acid of vitriol*, charged with as much phlogiston as is necessary to give to it the form of gas, and also with much of the earthy matter of the fluor. And he is confirmed in this opinion from the following observations:

1. That fluors contain phlogiston, appears evident from the effects of distilling them with nitrous acid; by

by which means nitrous gas, and a gas capable of producing a precipitation in lime-water, are formed.

2. It appears no less evident, that an earthy matter is raised along with this gas, from the crust which is precipitated from the gas, when water is added.

3. The gas obtained by applying heat to the water impregnated with fluor acid gas, possesses all the known properties of vitriolic acid gas; the water having deprived the acid of the earthy matter which gave to it the peculiar properties of the fluor acid.

4. When nitrous or marine acids are substituted instead of vitriolic acid, in the process of obtaining the fluor acid, none of the gas that is capable of forming a crust with water is produced. *Exp. and Observ. vol.* III. *p.* 288.

Mr. *Scheele* however affirms, that the fluor crust was produced, by distilling fluor with nitrous or marine acids.

Nevertheless, Dr. *Priestley* has remarked a difference between water impregnated with vitriolic acid gas, and water impregnated with fluor acid gas, namely, that the former is capable of being converted into ice by cold, but that the latter is not. He thinks that this difference may proceed from the earthy or fluor crust. *Id. vol.* III. *p.* 360.

M. *Monnet* endeavours to confirm by experiments the opinion of Dr. *Priestley*, that the acid obtained by distilling a mixture of spar and oil of vitriol, is not a peculiar acid, but he thinks that it is the acid of vitriol employed in the process which has been rendered volatile, by combining with the earthy principle of the spar. He found, after he had obtained as much acid as he could by distillation from that mixture of spar and oil of vitriol, that by adding water to the acid residuum, he obtained more acid by distillation; and that the residuum after this

ſecond operation was no longer acid. He concludes from this experiment, that the whole of the vitriolic acid is thus volatilized, and that the earth of the ſpar is rendered volatile by means of that kind of combination with the vitriolic acid, which is called *with exceſs of acid.* He further found, that a ſaline matter which he obtained by lixiviating the reſiduum, and which reſembled ſelenites, but was really different in its properties, being diſtilled in the ſame manner with vitriolic acid, the ſame volatile acid was thereby produced; and that the cruſt formed in the water of the receiver during the diſtillation of a mixture of vitriolic acid and ſpar, when deprived of its exceſs of acid by waſhing in water, became exactly ſimilar to this matter obtained by lixiviation of the reſiduum. From the acid liquor remaining in the retort, diluted with water, a white precipitate was thrown down on addition of fixed alkali, and a yellow precipitate on addition of a ſolution of mercury in nitrous acid, which yellow precipitate could not be ſublimed, and was not therefore corroſive ſublimate, according to the idea of the chemiſt, who has aſſumed the fictitious name of M. *Beullanger*, and who contends that the acid obtained in the diſtillation of ſpar with oil of vitriol is the marine. By fuſing ſpar with fixed alkali, M. *Monnet* could not obtain any neutral ſalt. *See Rozier's Journal, Auguſt* 1777.

The experiments of M. *Monnet* do not however decide the queſtion concerning the nature of the fluor acid. The acid which he obtained wanted the moſt characteriſtic property of the fluor acid, which is the power of corroding glaſs. Poſſibly there may be a difference among the ſtones called *fluors* or *fuſible ſpars.*

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## CHAP. X.

### *Of Alkaline Gas.*

105. NOT only the vapour of acids, but alſo that of *volatile alkali*, may be raiſed into a permanent gas by means of heat, as Dr. *Prieſtley* has diſcovered. Thus by applying the flame of a candle to a phial containing volatile ſpirit of ſal ammoniac, he expelled much vapour, which being received into a veſſel filled with quickſilver, continued uncondenſed by cold. When mild volatile alkali was employed, he obſerved that much of the gas which combines with alkaline and calcareous ſubſtances was alſo expelled. He therefore preferred the cauſtic volatile alkali, for the purpoſe of obtaining this alkaline gas. *Exp. and Obſer.* I. 163, *&c.*

106. Alkaline gas is very readily and copiouſly *abſorbed by water*, with which it forms a very ſtrong volatile alkaline ſpirit. It alſo *diſſolves ice* as faſt as if the ice were expoſed to a hot fire. This gas *unites with the marine and vitriolic acid gaſes*, forming concrete ammoniacal ſalts; and with the *gas of calcareous ſubſtances*, with which it concretes into oblong ſlender cryſtals. *Ibid.* Although volatile alkali readily acts upon copper, yet this metal was not affected by alkaline gas. *Id. vol. II.* 232.

107. Alkaline gas, mixed with air, was found to be inflammable. *Ibid.* *Cygna* ſays alſo, that air ſaturated with volatile alkali is inflammable.

Alkaline gas was encreaſed in its dimenſions by *electric ſparks* paſſing through it; and when as much of the gas, thus treated, was abſorbed by water as could be done, the reſiduum was inflammable. *Exp. and Obſerv. vol.* II. *p.* 240.

108. In the preceding chapters the ſeveral ſpecies of gaſes, hitherto known and diſtinguiſhed from each other, by their peculiar properties, have been deſcribed. But as two or more of theſe ſpecies are frequently obtained from the ſame ſubſtance, and by the ſame proceſs; the following chapters will contain ſome obſervations relative to the kinds and quantities of gas produced from certain ſubſtances, and in the laſt chapter will be added ſome conjectures and ſpeculations concerning the theory of theſe fluids.

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## CHAP. XI.

### *On the Gas extricated from putreſying Subſtances.*

109. A Permanently elaſtic fluid, or gas, eſcapes from animal and vegetable ſubſtances undergoing the putrefactive fermentation.

This gas conſiſts of two different kinds mixed together. One of theſe renders cauſtic alkalies mild, and precipitates lime-water, as Dr. *Mackbride* has ſhewn. The other kind of gas was obſerved by Mr. *Cavendiſh* to be *inflammable*. *See Chap. IV. on inflammable gaſes.*

In order to aſcertain the quantity and proportion of theſe two gaſes, Dr. *Prieſtley* put a piece of mutton, weighing four pennyweights and ſix grains, into a jar filled with quickſilver, and inverted into quickſilver, and he found that the quantity of gas emitted during the putrefactive proceſs, was, in bulk, equal to $2\frac{1}{4}$ ounces of water, of which quantity $2\frac{15}{200}$ ounce meaſures were of the former kind of gas, and the remainder was inflammable. It is obſervable, that all the inflammable gas was extricated in the beginning of the proceſs. *Exp. and Obſ. vol.* III. 344.

From

From 7640 grains of putrefying broth, (which contained about 163 grains of solid matter) one grain of inflammable gas was procured by Mr. *Cavendish. Phil. Trans.* 1766.

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## CHAP. XII.

### *Of the Gas obtained by Fire from Animal and Vegetable Substances.*

110. MUCH elastic fluid is produced in the distillation of animal and vegetable substances. Dr. *Hales* has ascertained the quantity of gas which he procured from many of these substances. From his *Analysis of Air*, the following summary of the results of his experiments is collected:

| | | | | |
|---|---|---|---|---|
| 1 cubic inch of *hog's blood*, yielded | 33 cubic inches of gas. | | | |
| ½ cubic inch of *deer's horn* - - - | 117 equal to one seventh of its wt. | | | |
| ½ cubic inch of *oak* | 108 | — | one third | ditto. |
| 388 grains of *Indian wheat* | 270 | — | one fourth | ditto. |
| 1 cubic inch of *pease* | 396 | — | one third | ditto. |
| 437 grains of *mustard seed* | 270 | — | one sixth | ditto. |
| 142 grains of dry *tobacco* | 153 | — | one third | ditto. |
| 1 cubic inch of *oil of aniseed* | 22 | | | |
| 1 cubic inch of *oil of cloves* | 88 | | | |
| 1 cubic inch of *honey* mixed with *calcined bones* | 144 | — | one ninth | ditto. |
| 1 cubic inch of *bees-wax* | 54 | — | one tenth | ditto. |

1 cubic

| | | |
|---|---|---|
| 1 cubic inch of *coarse sugar*, yielded | 126 cubic inches, | equal to one tenth of its weight. |
| 1 cubic inch of *tartar* | 504 | — one third ditto. |
| ½ cubic inch of *salt of tartar* | 112 | -- one ninth ditto. |
| ⅛ cubic inch of *human calculus* | 516 | |
| ⅛ cubic inch of *stones* taken from a human gall bladder | 108 | |

*Van Helmont* computes that of 62 pounds of *charcoal* 61 pounds may be reduced into gas by burning. *Complex. atq. mistion. elem. figm.* 13.

It may be remarked generally, that the elastic fluid, produced by fire from animal and vegetable matters, is chiefly a mixture of *calcareous gas*, described in chap. III. and of another gas which is *inflammable*, and which may be separated from the former by exposure to water; by which means the inflammable gas will be left alone, the other being almost totally absorbed by the water. The inflammable gas thus obtained separate from the other, is not quite pure; for I found that a gas obtained by distilling tartar, which did not shew any marks of its containing air when mixed with nitrous gas, being exposed to water and lime-water till no more could be absorbed, left a residuum which was inflammable, and which, on being mixed with nitrous gas, became turbid, and was a little diminished; which shews that the residuum contained a small portion of air, mixed with the inflammable gas.

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## CHAP. XIII.

### *Of the Gases in Mines and other subterranean Places.*

111. A Noxious gas is found in many caverns, as in the famous *Grotta del Cane*, in mines, wells, and other deep pits. This gas, which by *English* miners is called *Choke-damp*, is heavier than common air, and therefore lies chiefly at the bottom of pits; extinguishes flame; precipitates the lime of lime-water; and is noxious to animals: from these properties, which it possesses in common with the gas obtained from calcareous and alkaline substances, it has been reckoned to be of the same kind, as that which has been described under the name of *calcareous gas*. See Chap. III. *

112. Another kind of gas found in mines and other deep pits, is called *Fire-damp*, from its inflammability. It is lighter than air, floats near the roofs of mines, and is apt to catch fire and explode. This is one of the gases which have been enumerated under the name of *Inflammable gas*. *See Chap. IV.*

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* Miners who work in mines that are subject to this damp, generally carry down with them, into their pits, a lighted candle to try the salubrity of the air. They can, however, remain with safety several hours in pits where a candle cannot burn. I have seen them working in the shaft of a coal-pit several yards below the part of the shaft where a candle was extinguished. For, as has been already observed, in treating of calcareous gas, flame may be extinguished by mixing a smaller quantity of noxious gas with air than is sufficient to prevent respiration: but where the damp is so strong, that not only the flame of the candle, but also the redness of the burning wick is extinguished, the miners never venture to remain a minute, knowing that degree of damp to be quickly fatal to animal life.

## CHAP. XIV.

### *Of the Gas of Waters.*

113. AN elastic fluid may be expelled from *common water*, by *removing the pressure of the atmosphere*, or by *boiling*. But although the greater part of the air or gas may be expelled by these means from water, yet M. *de Luc* shews, from many laborious experiments, that water obstinately retains a certain quantity of air or gas, which cannot be extricated by boiling, by the air-pump, or by any other known means, than by a long-continued agitation in vacuo; and he further shews, that when water is thus deprived of all the air that can be separated from it, it then becomes capable of sustaining, without boiling, a much greater heat than can be given to it in its common state, even to 240° of *Fahrenheit*'s scale, or more. The elastic fluid contained in water, may be also separated by *freezing*. Accordingly *ice* is always observed to contain many bubbles.

From 54 cubic inches of well-water, Dr. *Hales* obtained one cubic inch of elastic fluid; and from a pint of pump-water Dr. *Priestley* procured one quarter of an ounce measure of a gas, in which a candle could not burn, but a mouse lived. *Exper. and Obs. vol. I.* 160. The water of another pump yielded one fourteenth of its bulk of gas. *Id. vol. II.* 223.

A much larger quantity of gas is contained in many *mineral waters*. Thus from 411 ounces of the water of *Rathbone place*, Mr. *Cavendish* obtained above 75 ounce measures of gas, of which quantity he observes, not above twenty measures were extricated before the water boiled. *Philos. Trans. vol. LVII.*

Some

Some authors talk of a much larger quantity of gas being contained in water. Thus *Mariotte* affirms that a bubble of elastic fluid, expelled by heat from water, did occupy, when reduced to the temperature of the atmosphere, a space, ten times greater than the space occupied by the water which had contained it.

But Dr. *Hales* suspects that part of this gas produced in *Mariotte*'s experiment, (which was made by applying heat to a drop of water included in a glass thimble filled with oil and inverted in oil) proceeded from the *oil*: for oil also contains a considerable quantity of gas, according to Dr. *Hales*'s experiments. *Hales, Appendix.*

Other mineral waters yield a very small quantity of gas by being heated. From 54 cubic inches of *Pyrmont* water, Dr. *Hales* procured two cubic inches of gas, which he seems to have erroneously considered as air. *Bath* water yields only one thirtieth of its bulk of gas, according to an experiment of Dr. *Priestley*; and of this quantity, one half had the properties of calcareous gas, and the other half of air in which a candle had burnt out. *Exper. and Observ. vol. II. p.* 223. Dr. *Hales* procured no more gas from two quarts of *Bath* water, than was equal in bulk to half a pea. *Appendix.*

114. Dr. *Hales* justly attributed the peculiar briskness and sparkling quality of *Pyrmont* and other mineral waters to the gas which he found was contained copiously in them. *Hoffman* also observed, that some mineral waters in *Germany* contained nothing saline, but that they abounded in a volatile principle, to which he gives the name of *sulphureous aereo-ethereo elastic spirit.* And Mr. *Venel* shewed in 1750, that the waters of *Seltz* were neither acid nor alkaline, but con-

contained one fifth of their bulk of an elastic fluid, to which they owed their peculiar properties: and he endeavoured to imitate this mineral water, by adding to a *French* pint of water two gros of mineral alkali, and a sufficient quantity of marine acid, to saturate the alkali. This mixture being made in a strait-necked close vessel, the gas which was expelled from the alkali by means of the acid was not allowed to escape; but it impregnated the water so strongly, that this water was found to contain twice as much gas as the native mineral water.

Mr. *Venel* does not however distinguish the gas contained in mineral waters from air.

Dr. *Seyp* of *Pyrmont* in the year 1736 considered this fluid to be the same as that which is found in the *Grotta del Cane*, and other subterranean places: and Dr. *Brownrigg* sent to the Royal Society a paper, in which the gas of *Pyrmont* and *Spa* waters is said to be analogous to the choke-damp or permanently elastic gas of mines, which is shewn in chap. XIII. to be that gas which is in this Treatise called *calcareous*. Phil. Trans. vol. LV.

Mr. *Cavendish* observed, that the gas obtained from the waters of *Rathbone-place* occasioned a precipitation in lime-water; and he is induced to believe, that the greatest part of it is of the same nature as the gas contained in calcareous earths: but he also found, that $\frac{875}{7500}$ of the elastic fluid contained in this water were air.

115. Mr. *Cavendish* discovered that calcareous earth is suspended and dissolved in the waters of many springs, by means of their contained gas. By an accurate analysis of the waters of *Rathbone-place*, he obtained, from 494 ounces of these waters, 271 grains of

of earth, which, excepting a few grains of magnesia, was of the calcareous kind. He further shews, as has been already remarked, that the gas obtained from calcareous or alkaline substances is capable of dissolving calcareous earth, that is, of making it soluble in water. It may seem extraordinary that this gas, which is known to precipitate the lime from lime-water, should also render this earth soluble in water; but the fact is uncontrovertible; for besides that this or some very similar gas is proved to be the medium by which the calcareous earth is kept suspended in *Rathbone-place*, and other waters, it is shewn by Mr. *Cavendish*, that if to lime-water, which has been rendered turbid by means of calcareous gas, more of the same gas be added, this water will, by this addition, be enabled to redissolve the precipitated lime, and will be again rendered pellucid. And indeed this phenomenon is analogous to other well-known chemical facts. For many of the precipitates, formed by adding alkalies to the solutions of metals in acids, may be redissolved by a further addition of the alkaline precipitant.

116. Mr. *Lane* has shewn that the gas of mineral waters is capable of *dissolving iron*; and that by means of this fluid, without any other menstruum, the iron is dissolved and suspended in many chalybeate waters. These chalybeate waters deposite their iron when exposed to air; for the gas, by means of which it is suspended, is volatile, and escapes upon exposure to air *. But

* Dr. *Hales* has observed, that when *mineral waters* had been deprived of their elastic fluid, they lost their power of tinging an infusion of galls. (*Appendix.*) And indeed *Van Helmont*, long before, knew that the escape of the spirituous gas, from these waters, by exposure to air, was accompanied with a loss of their acidulous

But Dr. *Brownrigg* has obſerved, that the gas does not eſcape from the water which it impregnates, unleſs the water be in contact with air; for when the *Pohun* water was excluded from air, but at the ſame time liberty was given for its gas to riſe into an empty bladder, the gas did not ſeparate from the water by any ſpontaneous motion, but on the contrary, it remained united with the water, when expoſed to the greateſt heats of our climate. When the impregnated water is thus excluded from air, the gas will eſcape but ſlowly with any heat leſs than that of 110° of *Fahrenheit*'s thermometer, although ſuch heat be ſufficient for the diſtillation of water; neither can this gas be wholly expelled by a heat of 160° or 170°, continued two hours. This adheſion ſhews, that the gas exiſts in the mineral water with the other ingredients in a ſtate of ſolution; and in the ſame proportion in which the gas is expelled, in the ſame alſo are the martial and earthy parts ſeparated. *See Dr. Brownrigg's paper on Pohun waters, Phil. Tranſ. vol. LXIV.*

There is reaſon to believe that the gas may be more intimately combined with the ingredients of ſome mineral waters than with thoſe of others, and cannot be ſo eaſily expelled. Dr. *James Keill* obſerved, that a mineral water near *Northampton* loſt its ſpirituous quality, by being long kept included in a *Florence* flask hermetically ſealed. The combination of the gas with the water may have been rendered more perfect by time. Perhaps the reaſon why ſo little gas can be extricated from *Bath* water, (ſee §. 113.) may be, that it is more intimately combined with that water,

dulous quality, and a depoſition of the ferruginous matter diſſolved in them. *Paradoxum quartum*, §. 2, 9, 10.

water, or united with other ingredients which retain and fix it more than in the waters of *Pyrmont*, and others which sparkle much.

117. Gas may be *separated from water*, not only by the means mentioned in §. 113, but also by addition of an acid, which occasions an effervescence, and consequently an escape of the gas. Hence the acidulous waters are made to sparkle, by adding juice of lemons, or *Rhenish* wine.

118. The discovery of gas being the principle to which the briskness and peculiar properties of the mineral waters called acidulous are principally owing, having been ascertained; and Dr. *Hales* and Mr. *Cavendish* having shewn, that the gas of calcareous substances was capable of being absorbed by water, it occurred to Dr. *Priestley*, that the artificial impregnation of water with gas might be applied to useful purposes, and that mineral waters might be thus imitated. It was observed, that the water which had been distilled from sea-water, although free from any saline matter, was not so palatable or brisk as pump-water. This defect Dr. *Priestley* proposed to supply, by impregnating the distilled water with the gas extricated from chalk by means of oil of vitriol. And he published an account of an easy method of effecting this impregnation. His method consisted in collecting a sufficient quantity of his gas in a bladder, and in forcing the gas from the bladder through a bent tube into the water intended to be impregnated; which water was contained in a bottle inverted into a bason filled also with water. The gas thus remaining in contact with the surface of the water within the inverted bottle, is gradually absorbed, and the absorption is hastened, by agitating the apparatus. The

water, by being impregnated, acquires the taste of the acidulous mineral waters; and accordingly this artificial impregnation of water with gas has been lately much practised, in order to imitate these mineral waters. Dr. *Percival* observed, that the water thus impregnated acquires more of the sparkling quality of *Pyrmont* water, by being kept some time. *Exper. and Observ. vol. I. p.* 32.

This impregnation of water with gas is much facilicated by Dr. *Nooth*'s invention of an elegant and well-contrived apparatus of glass vessels for this purpose, an account of which is published in the *Philos. Trans. vol. LXV. See also Plate, fig.* 4, *and the explanation.*

119. The gas contained in water is said by some authors to be *more expansive* than air is; that is, that by an equal diminution of pressure upon these two elastic fluids, the bulk of the former is much more enlarged than the bulk of the latter. *S'Gravesande* observed, that a bubble of the gas in water expanded so as to occupy a space 15000 times greater; when the common air suffered an expansion of only 300 times. And *Muschenbroek* affirms, that he has seen a particle of this gas expand itself to a size 46,656,000,000 times greater. But, he adds, such particles are not always to be observed in water; and he conjectures that this gas, as well as air, consists of particles of different densities and elasticities. *Introd. ad Philos. Nat.* §. 2051. 2063.

That these singular expansions of bubbles of gas in water appeared as is represented, cannot be doubted, when we consider the accuracy and ability of *s'Gravesande* and *Muschenbroek*. But that the gas of water possesses an elasticity so much greater than air,

air, is an inference not easily to be admitted. And may not this phenomenon be otherwise explained? Water and other liquids are known to retain so powerfully the air or other elastic fluids which happen to be united with them, that these elastic fluids cannot be *immediately* thence expelled, either by boiling or by removing the pressure of the atmosphere; but while the liquids remain freed from this pressure, the air or other elastic fluid separates from them very slowly and gradually, forming a bubble which becomes more and more large, from the gradual accession of exceedingly small and almost invisible particles of such elastic fluid. This very slow separation of air from liquors, and the gradual formation of bubbles, was particularly noticed by M. *de Luc* when he was making thermometers. It seems therefore probable, that the enlargement of the bubbles observed by the *Dutch* philosophers, did not proceed merely from an expansion of a given quantity of air or other elastic fluid, but principally from the accession of more particles of this fluid disengaging themselves from the water during the experiment, and uniting with the bubbles ready formed.

*Muschenbroek* says also, that by *doubling* the pressure he reduced the elastic vapours of a fermenting paste to a quarter of its former space: and he thinks that most elastic fluids are not subject to the same law as air is, namely, that the spaces occupied by them are inversely as the powers with which they are compressed. *Introd. ad Phil. Nat.* §. 2051.

As *Muschenbroek* does not relate the manner in which the abovementioned experiment was made, we cannot say whether some error might not arise from condensation of watery vapours, or from any absorp-

tion of gas. A different result however was the consequence of the following experiment.

I filled a bent tube open at one end only with some gas obtained by adding vitriolic acid to chalk. By pouring mercury into the tube, a quantity of this gas was included between the close end of the tube and the surface of the mercury. I measured the space occupied by the gas thus exposed to the compression of the atmosphere, and also of the column of mercury in the open leg of the bent tube above the surface of that fluid in its closed leg. I then varied the height of this column, by pouring more mercury into the tube, and I observed the respective diminutions of space which the gas suffered from the encreased compressions. By comparing the several observations which I had made, I found that the spaces occupied by the gas, under different pressures, were to each other inversely as their respective compressing forces, and consequently that this elastic fluid is subject to the same law, in this respect, as common air is. *

* The bulk of every permanently elastic fluid is probably in the inverse proportion to its pressure, with the same *heat*. But as concrete bodies are subject to very different expansions by equal degrees of heat, so also are gases. Dr. *Priestley* has made experiments to measure the expansions of several of these fluids, while the mercury of *Fahrenheit*'s thermometer was expanded 10 degrees. The proportions of these expansions to each other are expressed in the following table.

| | | | |
|---|---|---|---|
| Common air | 1.32 | Deflagrating air | 2.21 |
| Inflammable gas | 2.05 | Phlogisticated air | 1.65 |
| Nitrous gas | 2.02 | Vitriolic acid gas | 2.37 |
| Calcareous gas | 2.20 | Alkaline gas † | 4.75 |
| Marine acid gas | 1.33 | | |

† Dr. *Priestley* expresses some doubt of the accuracy of his experiments concerning alkaline gas. *Vol. III.* 347.

CHAP.

## CHAP. XV.

### *On Fulminating Gases.*

120. SOME gases are *so suddenly* extricated or formed from the substances containing them, by the heat applied, or by means of the action of the parts of these substances on each other, or by the concurrence of both these causes, that in the instant of their formation an *explosion* or *fulmination happens.*

121. A gas of this kind is produced by the *deflagration of nitre* with inflammable substances. Hence the explosion of *gun-powder*, and of the *fulminating powder* composed of nitre, salt of tartar, and flowers of sulphur.

The quantity of gas obtained from gun-powder was found by the experiments of Mr. *Robins** to be equal in bulk to 244 times the bulk of the exploded gun-powder, when this gas is compressed by the atmosphere and reduced to the same heat: and as the expansion of the air appeared, from his experiments, to be encreased four times by the heat of iron just beginning to be white, he infers, that if the elastic fluid of gun-powder be equally affected by heat as air is, its expansive force, in the instant of explosion, is nearly a thousand times greater than the pressure of the atmosphere; a force sufficient to produce the effects of gun-powder.

*Boyle* observed that the gas of gun-powder was *noxious* to animals; and Dr. *Priestley* found, that the gas obtained by applying heat to a mixture of nitre and sulphur was the *nitrous gas.* Exper. and Observat. vol. II. p. 90.

 122. Some

* On Principles of Gunnery.

122. Some *metallic precipitates* are capable of fulminating. The preparation called *fulminating gold* is well known. The gas produced during its explosion has not been examined.

Mr. *Bayen* has discovered that various *mercurial precipitates* fulminate, when they are triturated with about one sixth part of flowers of sulphur, and afterwards heated. Of these precipitates the following are the principal.

*a.* Precipitates made by adding a *fixed alkali, mild* or *caustic*, or a *volatile mild alkali*, or *lime-water*, to a solution of *mercury* in *nitrous acid.*

*b.* Precipitates made by adding *fixed alkalies mild* or *caustic*, or *lime-water*, to a solution of *corrosive sublimate* in water.

*c.* A precipitate or *mercurial calx* prepared by digesting, in a sand-bath, *turbith mineral*, with a solution of *fixed alkali* in water, till the precipitate became red.

Mr. *Bayen* remarks, that no detonation was produced by mixing these precipitates with powdered charcoal, and applying heat to the mixture; and also, that the detonation, by means of sulphur, was observed to be so much the stronger, as the precipitates were more deprived of their acid. Thus the precipitate from the solution of mercury in nitrous acid, by means of volatile alkali, detonated very weakly, till it had been previously deprived of much of its adhering acid by calcination: and no detonation was produced by the precipitate which had been made by adding volatile alkali to a solution of corrosive sublimate in water; for it appeared, upon exposing this precipitate to a subliming heat, that the whole of it was in the state of sweet mercury, and that consequently much acid adhered to it.

123. The

123. The detonation of nitrous and other fulminating powders, is an effect too striking not to have engaged the attention of philosophers. *Stahl* maintains that the water of the nitre is converted into air. Mr. *Macquer* very ingeniously conjectures that, in the operation, a *nitrous sulphur* is formed, which inflames at the instant of its formation. *See the article, Detonation of Nitre, of the Dictionary of Chemistry.*

Dr. *Black* is of opinion, that the fulminating gold derives its detonating property from some gas which adheres to it, and which it had received from the alkaline precipitant used in the operation. However this explanation may be applicable to the fulminating gold, it cannot be applied to explain the fulmination of the *mercurial precipitates* of Mr. *Bayen*; for some of these were precipitated by caustic alkalies, and by lime-water. Mr. *Bayen* thinks that the fulmination of these precipitates is the consequence of a commotion excited between the mercury and the sulphur at the instant of the combination taking place, by which cinnabar is formed. And this opinion is confirmed by the heat, and even spontaneous inflammation which happens when sulphur and crude mercury combine together.

Whatever be the cause which excites such commotions, the *detonation* itself consists in the sudden concussion which the air receives from the instantaneous production of an elastic fluid expanding itself with great violence. In the notes to the first *English* edition of the Dictionary of Chemistry I suggested, at the article *Fixable Air*, that the elastic fluid produced in the detonation of nitre was formed from the *nitrous acid* probably combined with the *inflammable principle*, and that these are *converted into the state of gas* by the violence of the action of this acid and of the inflammable matter

on each other. This opinion of the *conversion of nitrous acid into gas*, by the *detonation of nitre*, has been since confirmed and established by late experiments, which shew first, that the gas thereby produced is principally that which we have described under the name of *nitrous gas*; and secondly, that this nitrous gas is the nitrous acid in the state of *gas*, probably combined with inflammable matter, and is again convertible into the liquid nitrous acid, by being mixed with air.

The detonation likewise of Mr. *Bayen*'s mercurial precipitates is occasioned by the production of an elastic fluid; and I think that this fluid also proceeds from the conversion of some adhering portion of the acid, in which the mercury had been dissolved, into the state of gas, (together probably with some of the phlogiston of the metal or sulphur) by means of the violent heat and motion excited between the mercury and the sulphur in the act of combination, while the mercury is forced from its union with the adhering acid. For it appears, both from Mr. *Bayen*'s experiments, and from the analogy of other precipitations, that some acid always adheres to the precipitate; and probably also some of the alkaline or earthy precipitant. It is true indeed, that when *much* acid adheres, the fulmination does not happen, as Mr. *Bayen* remarks. The reason of which may be, that the combination between the mercury and sulphur is by this abundant acid so prevented or retarded, that the heat and motion requisite to effect the conversion of acid into gas are not produced.

It appears further, from Mr. *Bayen*'s experiments, that not only the nitrous acid but also the *marine acid* is *capable of detonation*, and, according to the above conjectures, of being *converted into gas*.

CHAP.

## CHAP. XVI.

### *Conjectures and Speculations concerning the Theory of Gases.*

124. WE daily see the same bodies assume very different appearances or states, under different circumstances; and of such changes, no instances can be adduced more curious and surprizing than those which we have described concerning the formation of the various kinds of permanently elastic fluids. We have seen that solid, hard, and dense bodies lose at once their cohesion, acquire a repelling force, and suddenly expand into a space many hundred or thousand times greater than that which they before occupied; forming rare, invisible, elastic fluids. We have also seen that the most expansive fluids can be again restored to a concrete state, and may conduce to the formation of very hard and solid bodies.

To explain these changes, exceeds, I fear, the limits of our present physical knowledge. Conjectures however may be admitted; which, as they are not intended to decide, do not establish or confirm errors, but may be useful, by suggesting certain questions to be ascertained by future experiments. With this view then only we proceed to the following speculations.

125. Many well known facts shew, that matter is endowed with two contrary qualities, an *attractive* and a *repulsive power*, of which sometimes one, and sometimes the other exerts itself in different circumstances. Natural philosophers have observed, that the particles of bodies attract each other within certain distances; and that, when they are placed beyond the sphere of each other's attraction, they begin to exert a repulsive power. In order therefore to change a co-

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hering concrete body into a repelling fluid or gas, is it not ſufficient that the particles of that body be removed to a diſtance from each other, greater than the ſphere of their attraction, that their repulſive force may begin to act †?

May not *heat*, which is known to expand all bodies, remove their particles to ſuch diſtances from each other, that their attraction ſhall ceaſe, and their repulſion commence? And is not this the mode of action by which heat raiſes water, mercury, and other volatile bodies, into elaſtic vapours; ſome of which by cold are again brought within the ſphere of each other's attraction, and are condenſed; while others, poſſeſſed of a ſtronger repulſive power, remain in an expanded ſtate, forming ſome of the permanent elaſtic fluids, called *gaſes*.

126. May not alſo a *violent motion* or *quick vibration*, excited among the minute particles of bodies, occaſion

† Thus *Sir Iſaac Newton* ſays, (*Optics*, *Quer.* 31.) "As in "algebra, where affirmative quantities vaniſh and ceaſe, there "negative ones begin; ſo in mechanics, where *attraction* ceaſes, "there a *repulſive* virtue ought to ſucceed. And that there is ſuch "a virtue, ſeems to follow from the reflections and inflections of the "rays of light. For the rays are expelled by bodies in both "theſe caſes, without the immediate contact of the reflecting or "ineffecting body. It ſeems alſo to follow from the emiſſion of "light; the ray ſo ſoon as it is ſhaken off from a ſhining body by "the vibrating motion of the parts of the body, and gets beyond "the reach of attraction, being driven away with exceeding great "velocity. For that force, which is ſufficient to turn it back in "reflection, may be ſufficient to emit it. It ſeems alſo to follow from "the production of air and vapour. The particles when they are "ſhaken off from bodies by heat, or fermentation, ſo ſoon as they "are beyond the reach of the attraction of the body, receding "from it, and alſo from one another with great ſtrength, and "keeping at a diſtance, ſo as ſometimes to take up above a mil-"lion of times more ſpace than they did before in the form of a "denſe body."

tion a similar separation of these particles, and a consequent change from a concrete to a repelling state? Thus the particles of fire and light are supposed by *Sir Isaac Newton* to be thrown off from ignited or luminous bodies, by the motion and vibration of their parts. May not also the violent intestine motion excited in the particles of bodies, during their *decomposition* and *solution by menstruums*, as of *metals by acids*; and also of bodies undergoing the *vinous*, *putrefactive*, or *other fermentations*, produce in the same manner the gases which are known to be formed in these several operations? For when any two united particles are torn asunder, by the superior attraction or affinity of a menstruum, or solvent, must they not, at the instant of separation, recede from each other with a force equal to that with which their disjunction was resisted; in the same manner, as the two parts of a cord, stretched till it breaks, recoil towards the opposite points of tension? And the effects of the violent separations of the particles of bodies, which occur in chemical decompositions, solutions, and fermentations, will appear very great, when we consider the *minuteness* of the particles engaged in these operations, and how much the activity, or force of the attraction and repulsion of bodies, depends on the minuteness of their size. For it is known, that the attraction of any two bodies to each other, encreases as the distance between them decreases, in some high ratio; and as the distance at which all the particles of any body can exert their attractive power upon any other contiguous body, may be supposed equal to the semi-diameter of the attracting body; therefore the particles of large bodies must exert that power at a greater distance than those of smaller bodies, and consequently the attrac-

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tive force of large bodies muſt be leſs than that of ſmaller bodies, relatively to the quantity of matter contained in each.

127. Some bodies are more diſpoſed than others to be changed from a concrete to an elaſtic ſtate. Thoſe which cohere with leaſt force, will moſt eaſily have their particles thrown out of the ſphere of each other's attraction. And this ſeems to be the caſe with all thoſe bodies which are called *volatile*, as water, ſpirit of wine, and ether. And is not even the *evaporation* of cold water, and of ſome other volatile liquids, eſpecially in vacuo, occaſioned by ſome of the particles, at the ſurfaces of theſe liquids, where they are not compreſſed by other particles, being thrown by the agitation, which generally prevails in fluid bodies, to ſuch diſtances, that their repulſive force can begin to exert itſelf*?

Thoſe bodies which are eaſily expanded to an elaſtic ſtate, are alſo eaſily reducible to their former ſtate, and are generally condenſable by cold into bodies of the ſame ſpecies, as they were of before their volatilization. For, as their coheſive power is weak, ſo alſo is their repulſive power; and therefore cold, which approximates the particles of bodies, is capable of bringing them again within the ſphere of each other's attraction.

But bodies, on the other hand, whoſe parts cohere ſtrongly, and which, therefore, cannot be disjoined without violent efforts, ſuch as thoſe which produce the ſolution and decompoſition of bodies, whether by heat,

* Some philoſophers have attributed the riſe of exhalations and of vapours to the diſſolving power of air, exerted upon the moiſture on the ſurface of the earth. But although this cauſe may concur, it does not ſolely or principally produce this effect; for water is known to evaporate not only in air, but alſo in vacuo.

heat, by acid menstruums, or by fermentations, form elastic fluids, whose repulsive power is stronger, and which cannot be condensed merely by cold. The violence of the effort employed in these operations, appears from the heat with which they are accompanied. From such bodies, therefore, are chiefly formed the uncondensable fluids, called *Gases* †.

128. Of all the concrete bodies which we know, none possesses so strong and general an attractive power as *acids* do; for they are known to unite and combine with water, oils, earths, and metals. Nor do perhaps any bodies resist their action, excepting those compounds which are already saturated with acid, as sulphur is. When we consider the great activity of acids, and also how much the activity of bodies depends on the minuteness of their particles, does it not seem probable, that the particles of acids are very minute, and that to this minuteness of size, these bodies owe their strong attractive dissolving power?

129. There is another body which never appears to us in a concrete state, unless when combined with other substances, but which seems strongly disposed to unite with every other class of bodies, excepting, perhaps,

† "The particles of fluids which do not cohere too strongly, "and are of such a smallness as renders them most susceptible of "these agitations which keep liquors in a fluor, are most easily se-"parated and rarefied into vapour, and in the language of chemists "are volatile, rarefying with an easy heat, and condensing with "cold. But those which are grosser, and so less susceptible of agi-"tation, or cohere by a stronger attraction, are not separated "without a stronger heat, or perhaps not without fermentation. "And these last are the bodies which the chemists call fixed, and "being rarefied by fermentation, become true permanent air. "Those particles receding from one another with the greatest force, "and being most difficultly brought together, which upon contact "cohere most strongly." *Newton's Optics, Quer.* 31.

perhaps, water, with which it does not seem to be capable of combining, but by the intervention of acids. This is the *matter of light*; those minute particles which have been repelled from the surface of the sun, and other ignited bodies; and are absorbed and combined with acids, and earths, forming the various combustible matters, vegetable, animal, and mineral *.

These matters it endows with the property of inflammability, and hence it is called by chemists, *Phlogiston*.

Now the amazing tenuity of the matter of light is well known; and from this property perhaps arises its extreme susceptibility of that motion on which heat depends, and the violence with which it combines with those substances which it most strongly attracts. From this susceptibility of motion, must not the particles of the matter of light be peculiarly disposed to be agitated and thrown from the sphere of each other's attraction, and to exert the repulsive faculty? Accordingly, not only light itself possesses eminently this repulsive faculty, but also the substances with which this matter is combined are thereby rendered more volatile, as numberless chemical facts demonstrate.

As therefore the matter of light is strongly disposed to become volatile, and to exert its repellent force; and as it imparts more or less of this property to the various substances with which it is capable of combining, it seems particularly adapted to form elastic fluids.

* "Are not *gross bodies* and *light* convertible into one another, "and may not bodies receive much of their activity from the par-"ticles of light which enter their composition?" *Newton's Optics, Qyer.* 30.

fluids. Accordingly, it may be doubted whether, in each of the above-described gases, some portion of phlogiston does not enter. But scarcely any substance is so much disposed to unite with phlogiston as acids are; and as these are endowed with so strong an attractive power, they are probably possessed of an equally strong repellent power, when they happen to be thrown into an elastic state, and consequently are very capable of being converted together with phlogiston into permanent gases. Accordingly we shall find, upon examination of the preceding history of these fluids, that in the formation of most of them, an acid and phlogiston enter into the composition of the substances employed.

Phlogiston is also much disposed to unite with alkaline and other earths, especially those that are metallic. And accordingly, among the fluids above described, a few will be found which seem to consist principally, if not solely, of phlogiston and some portion of earth.

As water is powerfully attracted by acids, and is itself disposed to assume an elastic state, (though not permanent) it may also enter into the composition of these fluids, and thus acquire, by means of the other component parts, a permanent elasticity.

130. From these substances, then, phlogiston, and acids, together with some portion of earth or of water, may not the several gases described in the preceding pages be compounded? To enable us to resolve this question, let us take a survey of these fluids: but it may be proper previously to obviate an objection which will readily occur, viz. that so many fluids, so different in their properties, should consist of so few and the same elements.

First,

First, it may be remarked, that a great variety of compounds might arise from the difference of the kinds of acids and of earths employed in the processes for producing gases. Thus by the same process, by varying the acid, may be produced, marine acid gas, vitriolic acid gas, or nitrous acid gas.

Secondly, this variety may, and does principally proceed from the diversity in the *mode of combination.* For if any two bodies, A and B, are capable of uniting and combining together chemically, there are two modes in which they can combine; the one in which A predominates, and the other in which B predominates. Thus air unites with, and dissolves a certain portion of water, (*see* §. 8.) and thus a compound is formed, in which air predominates. But water is also known to dissolve a certain portion of air, (*see* §. 9.) and a compound is thus formed, in which water predominates. Thus also ether dissolves a certain determinate proportion of water, forming a compound in which the ether predominates; and water dissolves a certain determinate proportion of ether, forming a compound in which the water predominates. Accordingly, if more water be added to any quantity of ether, than this quantity of ether can dissolve, (but not so much as to be able to form the whole ether into the compound in which water predominates) two distinct compounds will be formed, one floating upon the other, in one of which the ether predominates, and in the other the water predominates; and there will not be besides any other compound or mixture consisting of other proportions of these liquids. Thus too quicklime and water combine in two different modes, forming *flaked lime*, and *lime-water*; in the former of which the lime, and in the latter the water, predo-

predominates. All saline substances unite with water, either in a solid crystallized state, or in the state of a solution; in the former case, the saline substance, and in the latter, the water, being predominant. The two modes in which vitriolic acid and mercury combine, appear in the *vitriol of mercury* and in *turbith mineral*; in the former of which compounds the acid, and in the latter, the mercury predominates. The double mode of combination frequently appears in metallic allays, in which, although the component parts are diffused through each other in different proportions by violent heat, yet, when they are kept long in fusion with the least requisite heat, the precipitations and separations which take place, indicate the disposition to form differently proportioned compounds. Many more instances might be adduced to shew the different modes in which bodies that have a chemical affinity to each other are capable of combining: and indeed so many instances occur, that I am inclined to believe that it may be considered as a general rule, and a rule of the first importance, in the explanation of chemical phenomena.

When a greater number of elements or component parts than two unite together in the formation of a compound, they are capable of more modes of combination. Thus the number of modes in which three bodies may be combined is six, if every combination that is arithmetically possible could be formed into a chemical compound. Four elements might be combined in 24 different modes; five elements in 120 different modes, and so on. Now although our experience does not lead us to believe that every combination among three or more bodies, chemically related to each other, which is arithmetically possible,

can actually take place in the forming of compounds; yet, from the analogy of the two modes of combination which two elements, thus chemically related to each other, are capable of, as we have above explained, and also from the instances that are known of the various modes of combination, in which three or more elements are formed into different compounds, we cannot doubt that the number of modes does frequently encrease with the number of component parts, although not in the full arithmetical extent.

How much the properties of compounds, consisting of the same component parts, are affected by the different modes of combination, that is, how different they are, is too obvious to require any proof or illustration.

131. We now proceed to examine the constitution of the several permanently elastic fluids described in the preceding chapters, all which may be comprehended under the following seven classes.

1. *Acid gases.*
2. *Alkaline gas.*
3. *Inflammable gases.*
4. *Calcareous gas.*
5. *Nitrous gas.*
6. *Air.*
7. *Phlogisticated air.*

*Of Acid Gases.*

132. We have seen that the vitriolic, nitrous and marine acids may, when united with any inflammable matter, be converted by heat into those gases which we have called *acid*, because they seem to retain their acid properties, of acting upon the metallic, alkaline, and other substances, with which they combine when in a liquid state; and also, of uniting readily with water, by which they are reduced to their original state of liquid acid. As these fluids are not condensable by the cold of the atmosphere, they have been considered as gases; but from their easy reduction to their former concrete state, and from their retaining

ing their acid properties while in their expanded state, they seem to be of the more imperfect kind of those fluids. It may be observed, that these gases are not formed by any violent action, intestine motion, or decomposition of bodies; but that they are raised merely, as vapours are, by moderate heat. Do not then these gases consist of acids volatilized by means of water and phlogiston? Does not the acid part greatly predominate over the phlogistic in their composition; and is not the phlogiston in a very imperfect state of combination with the acid, because this acid is united with much water, and because water does not easily combine with phlogiston? And do not the acid properties of these gases depend on this imperfect combination with phlogiston, and on the predominancy of acid in their composition*?

### *Of Alkaline Gas.*

133. The elastic vapour raised by heat from *volatile alkali* was found to be not condensable by the cold of the atmosphere; and it has been described, as the abovementioned acid vapours have, under the name of *gas*. But it may be observed of both acid and alkaline vapours, that if upon further examination they be found not condensable by any cold which we can apply to them, and be therefore properly compre-



* That the vitriolic acid gas contains the same elements as sulphur does, appears from a fine experiment of Dr. *Priestley*, an account of which will probably be given in his fourth volume of Experiments and Observations, now preparing for the press, but which he has been pleased to allow me to mention here. He exposed some water impregnated with vitriolic acid gas to a long-continued heat in a glass tube hermetically sealed: after which, he observed that the inside of the upper part of the tube was coated with white crystallizations, that were found upon examination to be perfect *sulphur*. In this experiment the adhesion of the principles of the gas seems to have been so weakened by the water, that a part of them separated and formed this new compound.

hended under the definition of *gas* given in chap. I. they must be allowed to be of the most imperfect kind of permanently elastic fluids. For neither the acid nor alkaline elastic fluids can be considered as compounds formed, during their expansion into an elastic state, from decomposed and violently separated parts; but as merely the disjoined parts of the bodies, from which they are raised, retaining, while in their elastic state, the properties of these bodies; and capable of being reduced, when condensed by water, into concretes, or bodies similar to those from which they were formed.

*Of Inflammable Gases.*

134. We have seen that *inflammable gases* are formed from the vitriolic or marine acids acting on iron, zinc, or tin; from marine acid gas acting upon these metals, or upon almost any inflammable substance; from many inflammable compounds, by means of heat, as from coals, vegetable and animal substances, during the decomposition of these compounds; and from animal or vegetable matters undergoing the putrefactive fermentation.

In the abovementioned different kinds of inflammable gas, we may perceive that acids and inflammable matter are the principal ingredients, not only in the metallic solutions, in which the acid unites with the phlogiston of the metals, but also in the vegetable and animal matters, by the analysis, or by the putrefaction of which, inflammable gases are produced. For in these matters, the vegetable and animal acids abound; and from their inflammability, it appears that the acids are combined with phlogiston. The conversion of the marine acid gas into inflammable gas, by the action of that acid fluid on phlogistic substances, sufficiently shews that an acid enters into the

the composition of this inflammable gas. The inflammability also of the disengaged gas of hepar of sulphur can scarcely be supposed to arise from any other matter than phlogiston and acid.

Other kinds of inflammable gas have been described, in the production of which no acid is employed; such are the gases formed from metals merely by heat, or, by means of alkalies. These inflammable gases seem to consist of the same component parts as the metals themselves, that is, of phlogiston and earth in different proportions. In metals the earth predominates, but in this inflammable gas, the phlogiston predominates. And that the phlogiston in these inflammable gases is not pure and uncombined, may be inferred from its not being seized upon by the air as soon as they come into contact with this fluid; whereas heat, and even ignition, is necessary for the decomposition of these, as of other inflammable compounds. Are not all the inflammable bodies that we know, whether in a concrete or expanded state, compounds of phlogiston, united either with acids, or with earths; with this difference only, that the inflammable concretes, such as sulphur, oils, bitumens, and metals, are compounds in which the acid or earth predominates over the phlogiston, and the inflammable gases are compounds in which the phlogiston predominates over the acid or earth.

We have remarked, (§. 127.) that the most perfect gases are formed by a violent separation of parts. Now, in all the modes of forming inflammable gas, the substances are dissolved or decomposed, and their parts violently torn asunder. The inflammability also of this gas is greater, when the heat is suddenly applied, or when the solution proceeds with violence.

And accordingly, the properties of this gas indicate it to be of the most perfect kind; for, it is the rarest, and the most immiscible with water, of any known gases. These properties probably proceed from the phlogiston which seems to abound in this gas.

Iron, zinc, and tin, are the metals from which inflammable gases are most easily produced: and the reason seems to be, that these metals, when dissolved by acids, do most easily part with their phlogiston, as chemists have often observed.

## *Of Nitrous Gas.*

135. We have seen that inflammable gases have been formed by means of the vitriolic, the marine, the vegetable, and the animal acids. But no method has been yet discovered of making a perfect inflammable gas, by means of the nitrous acid; although we have seen some approaches towards it, §. 86.* Nevertheless, the *nitrous gas*, described in chap. V. seems to be somewhat analogous in its composition to inflammable gas. For it is formed from an acid acting upon metallic and phlogistic substances; and the combination of phlogiston with the acid seems to be so intimate, that it suppresses the peculiar qualities of the

* Since the above was sent to the press, Dr. *Priestley* has been so obliging as to communicate a very curious experiment which he has lately made. He put a pot containing a mixture of iron-filings and sulphur into a jar filled with nitrous gas, and he observed, that after the gas had suffered the great diminution mentioned in §. 86. it encreased in bulk, and became *strong inflammable gas*. It retained its properties of nitrous gas till it was diminished to less than one third. Then it admitted a candle to burn in it with an enlarged flame; after which, it acquired the properties of *phlogisticated air*, and lastly it became, as we have said, strongly *inflammable*. Do not this, and the many other extraordinary instances of conversion of one gas into others, shew that they contain the same component parts differently proportioned and combined?

the acid; for this gas does not act as an acid upon metals or other substances; neither does it very readily mix with water, without the contact of air; and even when absorbed by water, it does not communicate its acid qualities to the liquid, till the water has been exposed to air, which decomposes the gas, and disengages its acid, as Mr. *Bewley* has well observed. The phlogiston however, in this gas, does not seem to be so perfectly combined, as it is in the inflammable gases, for the following reasons: 1. This gas is considerably denser, being as heavy as common air is*; whereas inflammable gas is greatly lighter. 2. It mixes more readily with water than inflammable gas does. 3. It parts with its phlogiston more easily; for, no sooner does air come in contact with this nitrous gas, than the phlogiston seems to pass from the latter to the former; and the acid thus deprived of the substance to which it owed its elastic state, is changed into a liquid concrete, or spirit of nitre. Although therefore nitrous gas cannot be inflamed, it appears to undergo a process similar to that of inflammation, namely, a separation of its phlogiston by means of air: and the difference seems to be, that the phlogiston is so firmly combined in the inflammable gases, that it cannot be separated from its acid by the superior attraction of the acid of the air, till its activity has been encreased by ignition; whereas, it is so much less perfectly combined with the acid in the nitrous gas, that it is separated immediately upon mixture with air.

From these reasons, I am inclined to think that a portion of water enters into the composition of this gas, and prevents such an intimacy of combination of



* Experiments and Observations, vol. I. p. 119.

the acid with the phlogiſton, as takes place in inflammable gaſes. And that water enters into the compoſition of this gas, is further rendered probable, from the copious production of nitrous gas, when the nitrous acid vapour acts upon water. *See Chap. VIII.* §. 99.

If this conjecture be juſt, the nitrous gas ſeems to be in an intermediate ſtate between the acid and the inflammable gaſes.

*Of Calcareous Gas.*

136. All thoſe gaſes which occaſion a *precipitation in lime-water*, have been generally comprehended under one claſs, and diſtinguiſhed by the name of *Fixed Air*. We have ſeen that they are produced from many different materials: 1. From calcareous, and from alkaline ſubſtances, by acids, or by fire: 2. From the combuſtion of any animal or vegetable matters, or from their decompoſition by heat, or by concentrated acids: 3. From animal and vegetable matters undergoing the vinous and other fermentations: 4. From metallic calxes by reduction, and ſometimes merely by heat, as from minium: 5. From ſome metallic and other ſalts, as green vitriol, by fire: 6. From air decompoſed by electricity: 7. From the deflagration of nitre, and in the various proceſſes in which the nitrous acid is uſed to produce gaſes: 8. From ſubterranean pits and caverns: 9. From mineral waters; and probably, they may be obtained from many other ſubſtances.

Perhaps, in all theſe gaſes, the ſame mode of combination prevails, although the acids which enter into their compoſition be different. From the above enumeration of the various modes of production, almoſt any acid ſeems capable of aſſuming this ſtate. But the animal and vegetable acids appear

pear to be peculiarly disposed to form this gas. For, we find from the experiments of Dr. *Hales*, that a very large proportion of the vegetable essential salts, as tartar, were converted into a gas of this kind; when these saline substances were decomposed by fire. In this operation, the acid disappears, and a gas is produced. For no gas exists in the tartar, or other vegetable body, till it be decomposed; the gas being a peculiar compound formed, during the decomposition of the vegetable matters, by fire, or by fermentation. Thus when tartar is united with fixed alkali, as in making *Rochelle* salt, the alkali, if caustic, is not rendered mild; and, on the contrary, if mild, its gas will be expelled by the tartar, as it would by any other acid: But, if this compound of tartar and caustic alkali, in which no gas exists, be burnt, the alkali remaining will be mild and effervescent; for the acid of the tartar being decomposed by the fire, and formed into a gas, a part of it will unite with the alkaline residuum. And if *soap*, which consists of caustic alkali and oil, be burnt, the alkali will be rendered mild, by the gas formed from the acid, which is known to be a constituent part of oil. Also, if nitre be deflagrated with any animal or vegetable matter, the alkaline basis of the nitre, which is not united with gas while combined with the nitrous acid, will, after the deflagration, be found to be united with gas, that is, rendered mild; whereas, if nitre be deflagrated with zinc or tin, which metals contain no acid capable of conversion into gas, the alkaline residuum will be caustic †. The

† The production of a mild alkali by deflagration of nitre with charcoal, and of a caustic alkali by deflagration of nitre with filings of zinc, or of iron, has been also noticed by Mr. *Beeley*. *Appendix to Dr. Priestley's third vol. of Exper. and Observ. p.* 387.

The existence of an acid, as a principal constituent, and even as the predominant part of this gas, is indicated by several of its properties. For it acts upon, and dissolves several earthy and metallic substances; it unites with alkalies and calcareous earths, and it effects their crystallization, as other acids do; it may be disengaged from these alkaline substances by stronger acids; it has been found to change the blue colour of the juices of turnsole, of litmus, and of cyanus, to red *; and it gives an acid taste to the water which it impregnates.

The acid quality, however, of this gas, is very weak, being probably counteracted by the other principles, as earth, or phlogiston, which in many instances are known to lessen or destroy the activity of acids †.

*Of Air.*

137. Of all the gases, *air* being of the greatest importance to us, has been most attentively examined by philosophers; a knowledge, however, of its constitution, and of the mode of operation, by which its singular effects are produced, has nevertheless eluded their inquiries. The existence of an acid, and even of the nitrous acid in air, has indeed been suspected, chiefly, from the necessity of air towards the formation of nitre, and

* Dr. *Priestley's* Exper. and Obs. vol. I. 31. and Appendix to vol. II. by Mr. *Bewley*.

† Signor *Fontana*, in a treatise entitled, *Ricerche Fisiche sopra l'Aria fissa*, attributes the acidity of the gas extracted from calcareous substances by means of oil of vitriol, to the acid employed, which he thinks may be dissolved in this gas, as water is dissolved in air, so intimately, that neither water nor alkali can separate this acid; and he thinks, that to this volatilized and combined vitriolic acid, the fixed air owes its medicinal qualities, the acid being thus rendered more efficacious than in its proper uncombined state. And also Signor *Landriani*, in his *Ricerche Fisiche intorno allo salabrità*

*dell'*

and from the analogous effects of nitre, and of air, in promoting inflammation. But, no experiments have been ever adduced to give such solidity to this conjecture, as those of Dr. *Priestley*, which shew that a fluid resembling air in all its known properties, and even possessing the peculiar properties of air in a much more eminent degree than the atmospherical air itself does, may be produced from nitrous acid mixed with almost any unphlogisticated earth.

Nevertheless we cannot, with certainty, infer, that the nitrous is the sole acid capable of forming fluids possessed of the properties of air, and consequently that the atmospherical fluid does certainly contain in its composition some of that acid. For a very strong resemblance, between two compounds, may arise from the similarity of the combination, although a component part of one compound may be of a different species from the analogous component part in the other compound. Thus we have seen, that inflammable gases similar in their properties, so far as we have examined them, are formed from very different acids, the vitriolic, marine, and others; and we have also seen, that those gases, which, from their similarity of properties, have been considered as being of the

*dell' Aria*, maintains, that the acidity of this gas proceeds from the acid employed in the operation of extricating it, and that when this gas is mixed with vapour or volatile alkali, an ammoniacal salt will be formed, which will be found to be a vitriolic ammoniac, if the acid employed had been the vitriolic, and a deflagrating nitrous ammoniac, if nitrous acid had been employed. Mr. *Bewley*, in the Appendix to Dr. *Priestley*'s second volume of Experiments and Observations, very well defends the opinion of the intrinsic acidity of this gas, and shews that the same indications of acidity are exhibited by gases extricated from volatile alkali and from magnesia, by heat, and without intervention of any foreign acid.

the ſame kind, and comprehended under the ſame name, *fixed air*, or *calcareous gas*, are ſimilar compounds, formed from very different ſubſtances, and probably containing in their compoſition very different acids. Theſe conſiderations prevented me, in the firſt Edition of this Treatiſe, from admitting the certainty of the nitrous acid being a neceſſary conſtituent part of the atmoſpherical fluid, although it was allowed that the production of one ſpecies of factitious air, by means of that acid, with various unphlogiſticated earths, was completely aſcertained by Dr. *Prieſtley*'s experiments. The recent experiments that have been ſince made, and related in §. 31. ſhew that a pure air may be obtained by means alſo of the *vitriolic acid*, and ſeem to leave no doubt, that fluids, poſſeſſing all the known properties of the atmoſpherical fluid, may be produced from more than one acid, and from various kinds of earths*.

Whether the earths employed in the proceſſes for making factitious airs enter into the compoſition of air, and in what proportion, are queſtions which cannot be aſcertained by the experiments hitherto made †. If

* An experiment is related by Mr. *Macquer*, which ſeems to ſhew that the *marine acid* is poſſeſſed of that very property which has been thought peculiar to nitrous acid and to air, and from which the analogy of theſe two ſubſtances has been chiefly deduced; namely, the property of maintaining combuſtion. "I introduced "(ſays that author) a lighted taper into a receiver filled with "vapours of highly-concentrated marine acid, through a tubu-"lated aperture. The flame of this taper, which was, before con-"tracted, white and almoſt without ſmoke, now became long, "pointed, yellow, and ſmoking, like the flame of burning tur-"pentine. But the moſt remarkable circumſtance was, that the "flame ſubſiſted a *much longer time*, than when the taper was in-"troduced into the ſame receiver filled with pure air."

† Dr. *Prieſtley* has made ſome experiments to aſcertain the proportion

If these earths are capable of being converted into elastic fluids, the resistance they make to this change renders it probable, that the fluids thus formed will be of the most perfect kind, and of the most permanent elasticity. *See* §. 127. The disposition which earths have to unite with phlogiston has been already noticed: but this tendency may exert itself much more powerfully, when it is not counteracted by the mutual cohesion of the particles to each other, by these being reduced to a fluid state. Hence perhaps the singular avidity with which air seizes upon phlogiston in combustion, respiration,

portion of nitrous acid, and of earth contained in the factitious air made from spirit of nitre and earth; but he does not consider them to be decisive. The question is important, but seems difficult of solution. The *Abbe Fontana* maintains, that this factitious air consists of spirit of nitre only, without earth or phlogiston; and he supports his opinion by the following experiments: He converted a given quantity of mercury into red precipitate; and he expelled from this preparation as much air as he could. Then he revived the mercury of the remaining precipitate, and found that the quantity obtained was equal to the quantity of mercury originally employed. Dr. *Priestley* has repeated the experiment; and found that there was a loss of about one eleventh part of the employed mercury: and Mr. *Magellan*, repeating the same experiment, lost about one third of the mercury. It appears then there must have been some error in the *Abbe*'s experiments; but the experiments of Dr. *Priestley*, and of Mr. *Magellan*, are not applied by these gentlemen to ascertain the quantity of earth actually converted into air: neither do I think that they *prove*, that any earth enters into the composition of the air; for in all the productions of air by heat, from earthy substances, the rising air elevates a great deal of earth, and this earth renders the air turbid, gives the appearance of white clouds, and at last subsides. Dr. *Priestley* observes, that the air is transparent while hot, and becomes turbid when cold; which shews that some earth is dissolved in the air, and that cold air not being able to keep dissolved so much [illegible] hot air, part of the earth that was dissolved while [illegible] hot, is precipitated by cold.

ration, mixture with nitrous gas, and in all the various phlogiſtic proceſſes, might be attributed to the earthy part which is ſuppoſed to enter into the compoſition of air, if the ſtriking analogy between the effects of air and of nitrous acid, in ſeveral of theſe inſtances, and alſo the ready converſion of nitrous acid into factitious air, did not give a greater degree of probability to the opinion, that an acid is the predominant principle in the compoſition of this fluid. Perhaps acids, while they are converted into air, ſuffer ſuch a change or decompoſition, as to be deprived of the ſpecific properties which diſtinguiſh the ſeveral kinds of acids from each other, while they retain only the general character of acid; and thus the ſame compound may be produced from different acids. But of all the acids, the *nitrous* ſeems to be the moſt eaſily convertible to the ſtate of air *.

138. How-

* The opinions which I have here maintained, that moſt of the known gaſes conſiſt principally of acid and phlogiſton; that the fluid called *calcareous gas*, or *fixed air*, is of an *acid* nature; and that the *nitrous* and *vegetable acids* are convertible into permanently elaſtic fluids, were ſuggeſted in the notes which I added to the firſt *Engliſh* edition of the *Dictionary of Chemiſtry*, publiſhed in 1771. Thus at the article *Fixable Air* are the following paſſages: "Have not the fluids, ſeparable from alkaline and metallic ſubſtances, ſome analogy with *acids*? Like acids, they readily "*unite* with, and effect the *cryſtallization* of thoſe (alkaline) ſubſtances. As a *weaker* acid is extricated from thoſe ſubſtances "by a *ſtronger*, ſo is this (fixable) air by all known acids. Are "not the elaſtic fluids produced by the *deflagration of nitre*; and "by the *combuſtion* or *alkalization* of *tartar*, and of other *vegetable acid ſalts*, formed from the *acids* of theſe ſubſtances combined with the *inflammable principle*?"——"A permanently "elaſtic fluid or fixable air is produced by *deflagration* of *nitrous* "*acid* with any inflammable ſubſtance. In this operation the acid "diſappears, and an elaſtic vapour is produced. May we not "thence

138. However imperfect our knowledge of the constitution of the atmosphere may seem, the explanation of the singular properties of the air in maintaining fire and the respiration of animals, in diminishing nitrous gas, in calcining metals, and in being diminished by the various means already described, will be attended with no less difficulty and obscurity. The way to truth, however, must be felt for, when it cannot be seen; and, accordingly, we proceed in our conjectures.

We may perceive, that almost all the chemical changes which happen to bodies, are the result of decompositions, occasioned chiefly by the application of substances, whose attraction to some of the parts of these bodies is stronger than the attraction of the parts to each other. This general observation has been applied to explain the effects of air. It has been supposed that air, or its acid, have a stronger attraction to phlogiston than any other substance; and consequently,

"thence infer, that the *acid* is *converted* by combination with "some other substance, probably with the *inflammable matter*, or "by decomposition of its own substance, into elastic vapour?" *Vol. I. p.* 36. And in a note to the article *Mineral Waters*, it is said; "Does not the *solution of calcareous earths*, by fixable air, "confirm a conjecture concerning the analogy of this vapour with "acids?" *Vol. II. p.* 838. Since the publication of that work, this opinion has been further confirmed by many of the new facts which have been discovered; and the acid quality of the gas, called *Fixed Air*, has been noticed by other later writers. Thus M. *Bergman*, as Dr. *Priestley* informs us, (*Exper. and Observat. vol. I. p.* 31.) is induced, from the effects of this gas on the colour of vegetable flowers, to consider it as an acid, and to call it the *Aerial Acid*. And Mr. *William Beeyley* has added an Appendix to Dr. *Priestley*'s second volume, entitled, "Experiments and Ob-"servations, tending to prove that Fixed Air is the Vapour of a "*particular* Acid." Mr. *Beeyley* distinguishes this fluid by the name of *Mephitic Acid*.

ſequently, that, where any inflammable ignited body is expoſed to air, the phlogiſton leaves this body, and unites with the air.

The *deflagration of nitre* is alſo explained, by ſuppoſing that the nitrous acid poſſeſſes an attraction to the phlogiſton of the inflammable body employed, ſuperior to the attraction of the parts of that body. And the *detonation of fulminating gaſes* ſeems to proceed from the ſudden converſion of acid, together probably with ſome phlogiſton, into gas, as has been already ſuggeſted, §. 123.

The *calcination of metals* is conſidered by chemiſts as a ſlow combuſtion; and the air is ſuppoſed to operate in the ſame manner as in other combuſtions.

139. Various opinions have been formed concerning the mode of operation by which the *reſpiration of air* is neceſſary to the life of breathing animals. See *Haller's Phyſiology*, and *Experiments and Obſervations, vol. III. p. 55.* Of theſe opinions, that which ſeems moſt probable is given by Dr. *Prieſtley*, namely, that reſpiration is a true phlogiſtic proceſs, in which the phlogiſton, with which the animal ſyſtem abounds, is diſcharged from the blood by the lungs, and combined with the reſpired air. And accordingly, the air which has been reſpired, is found to have ſuffered the ſame changes which it does in other phlogiſtic proceſſes, that is, its bulk is diminiſhed, it extinguiſhes flame, and it occaſions a precipitation in lime-water, which ſhews that it contains ſome portion of calcareous gas. He further confirms this opinion, by the remarkable changes which blood undergoes by expoſure to air. Mr. *Hewſon* had diſcovered that blood received a florid colour from air during its paſſage through the lungs. See *Mr. Hewſon's Experimental*

*Inquiry*

*Inquiry into the Properties of Blood.* M. *Cygna* had alſo ſhewn, that a florid colour could be given to the under black part of the coagulum of blood, by expoſing this part to air; and that the upper ſurface of blood was black in vacuo. *Miſcell. Taurin. I.* 73. To theſe obſervations Dr. *Prieſtley* has added others equally important. He found that the change produced by air on the colour of blood, was not prevented by the interpoſition of a bladder, nor of the ſerum of blood; that blood was rendered florid in a more remarkable degree, by pure factitious air; that blood was rendered black by inflammable, nitrous, and calcareous gaſes, and alſo by phlogiſticated air; that by expoſing blood to air, this fluid was thereby phlogiſticated; and that by expoſing blood to the other gaſes, theſe ſuffered conſiderable changes, the bulk of the *nitrous gas* being thereby leſſened, and its property of being condenſed by mixture with air being conſiderably diminiſhed; the *inflammable gas* being thereby made to approach ſo far to the ſtate of air, as to be capable of effecting a conſiderable diminution of nitrous gas; and *phlogiſticated air* being alſo rendered capable of producing ſome diminution of nitrous gas. *See Exper. and Obſerv. vol. III. p.* 55, *&c.*

140. Dr. *Prieſtley* alſo conſiders the effects of *mixing nitrous gas with air* as a phlogiſtic proceſs, in which the air deprives the gas of its phlogiſton; and he ſuppoſes, that, in all thoſe inſtances where air is diminiſhed by liver of ſulphur and other phlogiſtic ſubſtances, the air attracts and combines with the phlogiſton of theſe ſubſtances, and becomes thereby *phlogiſticated.*

If it ſhould be aſked why the phlogiſton of inflammable bodies cannot be ſeparated without heat, and

even ignition; whereas this phlogiſton may be ſeparated from nitrous gas, from the blood in reſpiration, from liver of ſulphur, and other phlogiſtic bodies, merely by contact of air; may we not anſwer, that, in the latter inſtances, the phlogiſton is but ſlightly attached, and eaſily ſeparated; whereas, in inflammable bodies, it is ſo intimately combined, that it cannot be ſeparated, till the parts of theſe bodies have been thrown into violent agitation by heat, their coheſion diminiſhed, the volatility and activity of the phlogiſton encreaſed, and its combination with air thus facilitated? And may not the intenſe heat, flame, and other effects of burning bodies, proceed from the agitation excited among their moſt active parts, from the violence with which they are torn aſunder from each other, and from the rapidity with which the minute and elaſtic particles of air and phlogiſton ruſh into union? For, in what does *heat* conſiſt, but in the exceedingly quick vibrations of the particles of burning bodies; or *light*, but in the extreme rapidity and force with which the moſt active particles are thrown from the ſurfaces of theſe bodies?

If it ſhould be aſked why air, or, at leaſt, why the factitious air, which is produced from nitrous acid, ſhould take phlogiſton from nitrous gas, which is alſo formed principally from that acid; may we not anſwer, that, although each of theſe fluids contain, in their compoſition, nitrous acid, yet they are very different combinations? For, if the nitrous gas contain, as has been above conjectured, a conſiderable portion of water in its compoſition, its attraction to phlogiſton will be thereby ſo weakened, that air may be able to deprive it of this eſſential part to its elaſtic ſtate; while the other parts in the compoſition of

of this nitrous gas, the acid and the water, shall be condensed and reduced to the state of liquid nitrous acid.

M. *Lavoisier* is of opinion, that nitrous acid is not a constituent part of air, but that air is a constituent part of nitrous acid, and that the nitrous acid, formed upon mixing nitrous gas with air, is composed of both these fluids united together, and therefore that the nitrous gas does not contain the nitrous acid, but only a substance proper to form it, by combining with air.

Whence proceeds the heat that is observed upon the mixture of nitrous gas with air? May it not be a necessary consequence of the condensation which instantly happens upon the mixture of these two fluids? For, is it not an universal rule, that cold is produced by the expansion of bodies into a rarer state; and heat by their condensation? Hence the cold produced during the evaporation of fluids, and during the rarefaction of air, by means of the air-pump; and hence the heat which is communicated by vapours during their condensation, which has been observed to be much greater than can be communicated by an equal quantity of any concrete matter heated to the same temperature.

Hence also the heat that is observed to accompany *fogs*, which are nothing but condensed vapours. Are not the other diminutions of air, and condensations of elastic fluids, also accompanied with heat *?

 141. The

* Heat is generally produced, while two substances combine, and their combination is accompanied with condensation; that is, when the new compound occupies less space than its constituent parts did before their union. But the combination of phlogiston with air is always accompanied with condensation, as appears from the diminution of the air in all phlogistic processes. May not then the heat produced by the union of air with phlogiston in the lungs of animals, during their respiration, be one cause of *animal heat*?

141. The *alteration produced in air*, by the *phlogistic processes*, is very remarkable. Air, by this phlogistication, seems to be converted into two distinct compounds, *phlogisticated air*, and *calcareous gas*, both which are very different in their properties from air. While the phlogiston unites with that part of air to which it seems to be most disposed, and forms with it the new compound *phlogisticated air*; the other parts of air, less disposed to unite with phlogiston, are precipitated, forming another compound, which, from its property of occasioning a precipitation in lime-water, appears to be the fluid described under the name of *calcareous gas*. We might suspect that this gas proceeded from the burning body, or substances, on which the air exerts its action, if we did not know that the same gas was produced when air is decomposed by electrical sparks passing through it.

Whether this gas be precipitated from air; or be a compound formed from the decomposed parts of the burning substance; or, lastly, whether some gas of this kind may not proceed from both these causes; we nevertheless can scarcely doubt that some part of the air is separated, fixed and combined with the burning substance. This opinion is confirmed by the following experiment of M. *Lavoisier*.

He burnt some phosphorus under a bell, the inner surface of which was moistened with distilled water. The quantity of phosphorus employed was 186 grains. Of this quantity thirty-two grains remained unconsumed; and therefore 154 grains were actually burnt. The vapours of the phosphoric acid being condensed by means of the water, with which the bell was moistened, were collected and weighed in a narrow-necked vessel; by which means he found, that the weight of the

the acid liquor exceeded the weight of an equal bulk of distilled water 243¼ grains, which was 89¼ grains more than the quantity of phosphorus consumed. These 89¼ grains could not be water attracted by the phosphoric acid, for the specific gravity of the liquor could not have been thereby encreased; and he therefore infers, that this accession of matter must have proceeded from some part of the air absorbed during the combustion.

In one instance however of air being diminished, no calcareous gas is precipitated, namely, the calcination of metals, which is considered as a combustion. Dr. *Priestley* alledges ingeniously, that the gas is formed in this as in other instances, but is absorbed by the calcining metal, and that this is the part of air, by the absorption of which, metals acquire weight during their calcination. This absorption of gas would be rendered more probable, by the consideration that, during the reduction of metallic calxes, a quantity of this calcareous gas is obtained, if the addition of inflammable matter necessary for such reduction did not leave some suspicion, that this matter *might* possibly furnish the gas thus produced.

142. The weight gained by metals during their calcination, is a fact too extraordinary not to have employed the ingenuity of philosophers in explaining its cause. *Boyle* and *Lemery* have attributed this encrease of weight to the particles of *fire* or *flame*, which they supposed were absorbed by metals during their calcination. *Charas*, a chemist cotemporary with *Lemery*, ascribes this effect to the *acid* of the *wood*, or of the *coal* employed in the calcination.

M. *Venel* and M. *Morveau* maintain, that this encrease of weight is not occasioned by the addition of

any

any ſubſtance to the metallic matter, but by *depriving* this matter of its *phlogiſton*. For theſe philoſophers pretend, that phlogiſton is endowed with a power contrary to that of gravitation, namely, of receding from the center of the earth, and thereby of rendering bodies, of which it makes a part, lighter than they otherwiſe would be. It is evident that a doctrine attributing to this phlogiſton (a ſubſtance which is not the object of any of our ſenſes) a property directly contrary to *gravitation*, which is an undoubted property of all thoſe ſubſtances that are the objects of our ſenſes, requires to be ſupported by very deciſive experiments, and unequivocal arguments.

As the air is diminiſhed by the calcination of metals, while theſe, at the ſame time, gain an acceſſion of weight, we cannot heſitate to aſcribe this acceſſion to the abſorption of air, or of ſome part of it, as has been already obſerved. *See* §. 13. *and note ſubjoined.*

Some inſtances have been mentioned (§. 26.) of metallic calxes yielding pure air by means of heat. That this pure air has been abſorbed from the atmoſphere, ſeems highly probable; and as the preparation of minium and of calcined mercury, requires a longer expoſure to the action of fire and of air, than that of other calxes, theſe metallic matters may perhaps be deprived more perfectly of ſuperabundant phlogiſton, or may abſorb a larger quantity of air than the calxes of other metals. Nevertheleſs, we can ſcarcely conſider the pure air thus abſorbed by minium and calcined mercury as the ſubſtance eſſential to them as calxes, and to which their additional weight is principally owing; for minium, after it has been deprived by heat of all its pure air, ſtill retains its calciform ſtate, and is heavier than the lead from which it was produced *.

143. Are

* The calx of mercury may indeed be revived or reduced by the heat of a furnace in cloſe glaſs veſſels without any addition of inflammable matter. And thus the ſame operation ſeems to effect the reduction of this calx, and the expulſion of air from it; which would ſeem to ſhew that its calciform ſtate is occaſioned merely by the preſence of this air; and accordingly Mr. *Bayen* has inferred from

143. Are not *metallic precipitates*, combinations of acid and metallic earth? And is not the revival of these precipitates effected by the combination of phlogiston with the adhering acid, forming a gas; and with the metallic earth, forming the revived metal?

144. The production of air, by water decomposing or absorbing part of the calcareous and other gases, §. 25; the precipitation of calcareous gas from air, by the several phlogistic processes; and the several instances above mentioned of nitrous, inflammable, and other gases being so altered by various substances, as to lose their specific characters, and to approach to that of air; seem to shew that these fluids contain in their composition the same elements, and that their differences arise principally from the different proportions of these elements, which take place in different modes of combination.

145. We may easily perceive that many important questions remain to be ascertained on the subject of this Treatise: And although we are highly indebted to the sagacity and industry of those philosophers who have led us to our present state of knowledge, yet much more remains undiscovered to excite and recompense the zeal of future labourers in this fertile and still new field of science.

When we shall be able more fully to ascertain the con-

from this fact, that calxes may be revived without addition of phlogiston, and that the theory of *Stahl*, which makes the calcination of metals to consist in the depriving them of phlogiston, is thereby overthrown. But a conclusion from a single fact, subversive of a theory founded on the general course of appearances, ought to be very cautiously admitted. For it may be doubted, whether the very small quantity of phlogiston, that may be necessary to the revival of the calx of mercury, may not pass through glass vessels softened by heat. Although mercury may not be capable of so perfect a calcination as the imperfect metals, nevertheless it is so far changed by the combined action of air and fire, as to lose not only its metallic appearance, but also, like other volatile metallic substances, to be rendered considerably more fixed when exposed to heat. It is even said to sustain a *fusion* or *vitrification*, like other metallic calxes, when exposed to the pure heat of a burning glass. *See a note of Dr. Lewis, in his translation of Newman's Chemistry, vol. I. p.* 134.

conſtituent parts of the ſeveral gaſes, the proportions of theſe parts to each other, and the circumſtances neceſſary to each mode of combination; we may then perhaps be enabled to diſcover the various compoſitions, decompoſitions and changes, which theſe fluids ſuffer in many natural operations. We may alſo perhaps be enabled to trace the ſame ſubſtance through a great variety of forms. Thus we may obſerve the oily concrete acid of vegetables undergoing its various changes through the different periods of vegetable life from ſeed to maturity; till, by the vinous or other fermentations, or by fire, it be diſengaged from the more fixed earthy matters, which were united with it, be more perfectly combined with phlogiſton, and aſſume an elaſtic ſtate. In this ſtate, it may mix with the atmoſphere, and conduce perhaps to ſome of the ſtriking phenomena which happen there; *or*, be abſorbed by the humid vapours floating in the air, and again conveyed by theſe vapours into the organs of vegetables: thus paſſing along in that perpetual circulation of matter, which makes the Proteus-like face of Nature, an ever-varying, pleaſing picture. Or, if we may be indulged a bolder imagination, where our yet infant experience cannot reach; may not theſe fluids, while raiſed into their elaſtic ſtate, undergo further changes? May they not be decompoſed and rarefied into the moſt active elements, and while they advance in this progreſſion of ſubtilization, may they not acquire new properties and powers, unknown in denſe matter? May they not then pervade all bodies, and become that highly elaſtic *ethereal medium*, which, as *Sir Iſaac Newton* † conjectures, may be the proximate cauſe of *coheſion*; of *gravitation*; of *electrical attraction* and *repulſion*; of the *refraction*, *reflection*, *inflexion*, and the *heat* of the *rays* of *light*; of *animal motion*, and of *animal ſenſation?*

† *Optics*, *Quer.* 19, 20, 21, 22, 23, 24, and *Principia Mathem.* §. *ultim.*

THE END.